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THE EFFECT OF RADIATION TECHNIC AND THE EARLY DIAGNOSIS OF CARCINOMA OF THE UTERINE CERVIX ON THE FIVE-YEAR GOOD END-RESULTS[1]

A STUDY BASED ON 488 PRIMARY CASES

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THE radiological and surgical methods of treatment of carcinomas of the uterine cervix have been technically so perfected that further improvement in the five-year good end-results, commonly called cures, may probably not be expected. The absolute curability percentages, reported from different clinics, vary from 20 to 25 per cent, while the relative curability percentages of the clearly localized carcinomas vary from 75 to 90 per cent. If the patients came for treatment during the early stage, then the control of cancer would be achieved.

Therefore, a study of five-year good end-results obtained in 488 primary carcinomas of the cervix was made (1) to investigate the influence of radiation technic on the end-results, and (2) to discuss the possibilities of very early diagnoses. These studies are herewith reported.

In 1928[2] the writer reported the five-year good end-results obtained with the technic of combined radium and roentgentherapy in 332 cases of primary carcinomas of the uterine cervix. It was shown that the percentage of absolute cures increased with the progress of development of roentgentherapy, and, therefore, an increase in the total roentgen dose. The radium dose, 50 mg. radium element filtered with 2 mm. brass and 3 mm. para rubber, has remained the same, namely, from 4,500 to 4,800 mg. radium element hours, though the continuous application of the dose in one sitting was changed to a 12-hour daily interval method, and, finally, to an 8-day interval method, giving one-third of the dose at each sitting. A study of the relative end-results of each Clinical Group showed that, in the clearly localized growth of Clinical Group 1, they amounted to 78.27 per cent cures.

Since 1923, another change in technic has been made. A water-cooled Coolidge treatment tube was installed, permitting activation of the tube with from 25 to 30 ma. at from 200 to 225 kilovolts. The application of the roentgen radiation dose was distributed to five séances every third day, applying one-fifth of the calculated dose to each field at each sitting. The total radiation dose to each field was 1,200 r, without back-scattering.

The number of fields and the total roentgen dose were calculated from the size of the patient. An attempt was made to

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, in St. Louis, Nov. 30–Dec. 4, 1931.

[2]SCHMITZ, HENRY, and HUEPER, WILLIAM: The Prognostic Value of the Histologic Malignancy Index and the Clinical Grouping of Carcinoma of the Uterine Cervix. RADIOLOGY, November, 1928, IX, 361-369.

TABLE I

FACTORS USED IN ROENTGEN TREATMENT FOR EACH PERIOD TO SHOW PROGRESS IN DEVELOPMENT OF TECHNIC

Periods	1914-1919	1920, 1921	1922, 1923	Since 1924
Transformer	Snook Cross-arm Type		Cross-arm Type to deliver 300 K.V.	
Type of Tube	Standard Coolidge Treatment with broad focus		200 K.V. air-cooled Coolidge	250 K.V. water-cooled Coolidge
Peak Kilovoltage	110	140	211	211
Filter: Copper plus Aluminum	6 mm. Al	0.5 mm. Cu plus 1 mm. Al	1 mm. Cu plus 1 mm. Al	0.75 mm. Cu plus 1 mm. Al
Focus-skin Distance	25 cm.	65 cm.	65 cm.	65 cm.
Size of Fields	25 sq. cm.	225 sq. cm.	225 to 400 sq. cm.	225 to 400 sq. cm.
Number of Fields	8 to 20	2 to 5	2 to 5	2 to 5
Dose to Each Field	150 ma.-min.	1,050 ma. min.	1,000 ma.-min.	1,250 ma.-min.
Interval	8 to 20 days One field daily	One hour daily 6 to 15 days	One field daily 2 to 5 days	5 x 250 ma.-min. Every third day to each field
Depth Dose at 10 cm.	About 20 per cent	About 35 per cent	48 per cent	44 per cent
Units in r			800 without back-scatter	1,200 without back-scatter

attain a roentgen dose of two threshold erythema doses at the cervix. Table I gives the factors used in the roentgentherapy for each of the four periods. Table II gives the five-year good end-results for each period, the relative cures for each Clinical Group in each period, and a summation of all the cases treated from 1914 to 1927.

I shall not dwell on the influence of the radiation dose in the arrest of carcinoma. Those interested are referred to the reports in the literature.[3, 4]

The perusal of Table II brings out two facts:

1. The better curative end-results obtained with an increase in the roentgen dose, as the radium dose has been the same during the entire series.

2. The high percentage of cures attained in the localized, *i.e.*, Clinical Group 1, carcinomas.

It is evident that the percentage of cures varies inversely with the development or extent of the growth. The relative curability in the beginning, clearly localized Clinical Group 1 cancers is from 75 to 90 per cent; in the doubtfully localized Clinical Group 2 cancers, from 35 to 50 per cent; in the Clinical Group 3 cases, involving the parametrium, when the mass retains a fair degree of mobility, from 10 to 25 per cent, and in the terminal, fixed carcinomas, *i.e.*, Clinical Group 4 cases, it is practically zero.

Clinical Group 1 carcinomas are incipient cancers which are clearly limited to the cervix and, as a rule, have not yet caused symptoms. They are, also, internal cancers, which the patient is not able to see or feel, as is the case in skin or breast tumors. It is, therefore, obvious that the physician must attempt to discover them.

Before discussing early diagnosis, several

[3] SCHMITZ, HENRY: Technic in Pelvic Irradiation. RADIOLOGY, December, 1931, XVII, 1230-1242.

[4] SCHMITZ, HENRY: The Value of Short Wave Roentgen Rays and Radium in Carcinomas of the Uterine Cervix. Read before the American Association for the Advancement of Science, Pasadena, Calif., June 15–20, 1931.

TABLE 11

	1914-1919					1920 and 1921					1922 and 1923					1924 1927				
Clinical Group	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
Total number admitted	5	16	76	35	132	9	13	26	29	77	9	19	59	36	123	12	14	61	69	156
Total 5-year good end-results	5	7	7	0	19	6	6	2	0	14	7	7	11	0	25	10	6	16	3	35
Percentage 5-year good end-results	100	43.75	9.21	0	14.39	66.67	46.75	7.69	0	18.38	77.78	38.64	18.65	0	20.32	83.0	42.85	26.23	4.35	22.43

Grand Total 1914-1927

Clinical Group	1	2	3	4	Total
Total number admitted	35	62	222	169	488
Total 5-year good end-results	28	26	36	3	93
Percentage 5-year good end-results	80.0	41.94	16.36	1.72	19.14

facts of general importance should be mentioned.

1. Cancer does not start in healthy tissues or organs.

2. Cancer begins in a spot or focus the cells of which at first are not malignant.

3. Chronic irritation causes this spot, or works on this nodule, producing the changes characteristic for malignancy.

4. All tumors must grow to some extent before causing symptoms.

5. The discovery of cancer during the symptomless period would put us in contro of the disease.

6. If the physician became "cancer-minded," *i.e.*, would learn always to think of the possibility of the presence of a malignant disease in chronic tissue changes, then diagnosis would be rendered without delay.

7. The avoidable delay, caused by the physician in placing the patient under observation instead of insisting on an immediate diagnosis and immediate treatment, is responsible for the poor end-results of treatment.

The diagnosis of carcinoma should include: (1) The macroscopic appearance; (2) the histologic structure; (3) the extent of growth development; (4) the symptoms. It is obvious that each one of these characteristics undergoes an orderly sequence in development from the beginning to the terminal stages. An intimate knowledge of these factors is a prerequisite to early diagnosis.

THE MACROSCOPIC FINDINGS

The macroscopic picture of cancer varies, depending on the type of growth, whether it is endophytic or exophytic. The sequence of changes in the endophytic type are nodule, ulceration, necrosis, and, finally, sloughing with crater formation. In the exophytic type, the changes are nodule, papilloma, cauliflower growth with necrosis, and, finally, sloughing with crater formation.

As benign nodules are more frequently seen than malignant ones, the cancer nodule is recognized with difficulty. It cannot be diagnosed by inspection or palpation. It does not cause symptoms. The Chrobak-Clark sign may be presumptive. If bright red blood appears when a nodule is touched with a dull-pointed object, and the arterial bleeding continues for some time, then one may presume that cancer is probably present. But a positive diagnosis rests on an immediate diagnostic excision of the nodule within the surrounding healthy tissue and an immediate frozen section diagnosis. Procrastination by observation must never be practised.

The beginning ulcer and papilloma are also difficult to diagnose because ulcers and papillomas are more frequently benign than malignant. The ulcer results from the peculiar tendency of the central carcinoma cells to degenerate, due to the poor blood supply. The papilloma tends to grow outward, but here, also, the central cells degenerate and become friable early. Such small ulcers and papillomas bleed when touched. "Contact bleeding" is the first symptom of cancerous tumors. A diagnostic excision should be made within the healthy tissues, followed by an immediate frozen section diagnosis to rule out malignancy.

Necrosis is manifested by friability of tissue. The growth has the consistency of brain substance. On withdrawal the examining finger may bring out sufficient material for microscopic examination to corroborate the clinical diagnosis. The periphery of such tumors, which is indurated and nodular, clearly invades the adjacent tissues. Arrosion of blood vessels causes spontaneous hemorrhages, while necrosis produces discharge.

Crater formation, with irregular and indurated walls, is an evidence of the extensive sloughing of the necrotic and friable tumor particles. It is indicative of an advanced stage and is almost invariably associated with wide dissemination into and fixation of tumor to the pelvic fasciæ and bones. Pain is added to the symptoms of hemorrhage and discharge and it always signifies an invasion by the cancer of the deeper pelvic structures or the adjacent organs.

When cancer arises in sites not easily accessible to microbes, it is a chronic disease and may not destroy the patient's life for many years. Cancer in protected sites often grows silently and unsuspectedly, but when it is easily accessible to putrefactive bacteria, for example, in the alimentary or genital tracts, the primary lesion is readily colonized. Such sequences soon manifest themselves and may speedily destroy the patient. The virulence of cancer, as a rule, depends not alone on the malignant character but also on its septicity. Putrefactive microbes are the common cause of failure in attempts to relieve cancerous patients by gross surgical and radiologic methods.

THE MICROSCOPIC CHARACTERISTICS

The histologic characteristics of a carcinoma are:

1. The atypia or anaplasia of the epithelial cells.
2. The invasion or breaking through of the basement membrane.
3. The destructive tendencies in displacing or assimilating normal tissues and cells.
4. The formation of metastases, either by continuity into the adjacent tissues and organs, or by emboli in the regional lymph nodes or distant sites.

The microscopic diagnosis does not depend on the presence of all these factors. A diagnosis of cancer is justifiable without evidence of metastasis; it is valid without presence of destruction, and it is warranted in the absence of invasive tendencies. Early carcinoma is present when atypia or anaplasia alone are seen. The latter is characterized by blurring of the cell mass, downgrowth of the epithelium with preservation of the basal layer, abnormal behavior in

staining qualities, irregularity in the shape and size of the cells and the nuclei, and loss of polarity. Beneath the basal membrane, and in contact with this new epithelium, is an acute inflammatory exudate.

In the next step of development the round cells may break through the basal layer in places, coming in actual contact with the most recently produced epithelial cells. The basal layer has failed in its protective function.

These atypic or anaplastic changes present the earliest evidence of the incidence of cancer in the human subject. This, according to Bailey and Schiller, is the moment of change from benign to malignant—the cancer phase. What proceeds thereafter does so in spite of any additional external factors which thenceforward are present. It is, in itself, progressive and inevitable.

Microscopic examinations of tissues removed by biopsy or by amputation of the cervix require serial sections to find evidences of cellular atypia or anaplasia; otherwise it would be impossible to find very early carcinomas. They also preclude the treatment of suspicious looking chronic cervicitides with the electric cautery, as the method might destroy such beginning cancerous foci. Therefore, we are more and more inclined not to use the cautery but to employ minor surgical procedures to obtain tissue for microscopic examination. Thereby one is placed in a position to rule out malignancy.

THE EXTENT OF THE TUMOR

The extent or growth development is determined by a general physical examination and a special pelvic examination. The latter comprises inspection by speculum and endoscopes, bimanual vagino-abdominal and recto-abdominal palpation, instrumental palpation with sound or curette, and, eventually, x-ray diagnostic procedures. The location and size of the growth, the condition of the parametria and adjacent organs (vagina, bladder, and rectum), invasion of the regional lymph nodes, and distant metastases are ascertained by these methods.

The following questions should be answered:

1. *Is the cancer clearly localized?* Such a beginning nodule should have a diameter of about one centimeter and should be clearly limited and freely movable within the cervix. The entire uterus possesses normal consistency, elasticity, and mobility.

2. *Does doubt exist of the absolute localization?* Such a tumor may have already spread to one-half of the cervical wall. It is surrounded by an area of inflammatory reaction enclosing dendritic processes of carcinomatous tissue. The area is reddened, edematous, or of doughy consistency. Mobility of the uterus is impeded, due to loss of elasticity of tissue, especially of the paracervical connective tissue.

3. Are the parametrium or regional lymph nodes involved, and are the invaded structures mobile or fixed?

4. Have metastases or extensions occurred to the bladder, vagina, and rectum?

5. Has distant metastasis taken place?

The answers to these five questions permit of a clinical grouping as follows: Group 1, the clearly localized growth; Group 2, the doubtfully localized growth; Group 3, the invasive growth in which the invaded parametrium or lymph nodes are movable, and Group 4, the disseminated and fixed growth, including *(a)* the frozen pelvis; *(b)* invasion of bladder, vagina, or rectum, and *(c)* distant metastases.

Inflammatory infiltration may complicate a uterine carcinoma. Nodular infiltration means carcinoma, especially if the uterine tissue is continuous with the parametrial masses and the uterus is not displaced laterally, anteriorly, posteriorly, or superiorly. Fixation of the uterus occurs late in carcinoma and early in parametritis. It abates in the latter when resolution takes place.

Co-existing tumors, such as ovarian cysts and uterine myomas, may cause displacement of the uterus and impede its mobility, though the carcinoma may be in the initial stage.

SYMPTOMATOLOGY

The sequence of symptoms depends on the extent of the growth. The clearly localized nodular growth is free from symptoms; the doubtfully localized beginning ulcer and papilloma cause "contact bleeding"; the invasive, necrotizing carcinoma is accompanied by hemorrhage and discharge, and the crater-shaped, fixed carcinoma produces hemorrhage, discharge, and pain. Hemorrhage is the earliest and most alarming symptom, discharge the most repulsive and constant, and pain the most unfavorable symptom of cancer. A carcinoma causing pain is as a rule hopeless and incurable.

To the characteristic primary symptoms should be added the secondary or accessory symptoms resulting from invasion of adjacent organs, from compression of neighboring structures, from toxemia due to the septicity of the cancer, and from the cachexia occurring in all chronic and wasting diseases. Thus invasion of the bladder causes dysuria, pollakiuria, hematuria, pyuria. Invasion of the rectum produces tenesmus, discharge, bleeding, ribbon-like stools. Compression of the ureters terminates in hydronephrosis with eventual pyonephrosis, with deep, constant, unbearable pain in the side affected. Septic infection is accompanied by pyrexia, putrid discharge, malaise, and so forth, while cachexia is characterized by an extensive catabolism, with rapid loss of weight and strength. Accessory symptoms are always suggestive of an advanced state of cancer and signify a poor prognosis.

It may be concluded from Table III that the beginning nodule, the initial focus of carcinoma from which the disease progressively and inevitably develops, shows, on microscopic examination, a cellular atypia of the epithelium, as yet devoid of invasion, destruction, and metastasis. The nodule is clearly limited and the uterus retains normal mobility. The growth has not thus far caused symptoms. These findings characterize the earliest stage of carcinoma. The diagnosis must be made by biopsy.

How may one find the symptomless, clearly localized, and nodular stage of carcinoma of the cervix? The profession should educate women to report for periodic health surveys after infection, labor, and abortion, and yearly thereafter. If symptoms of leukorrhea, menorrhagia, or irregular bleeding occur, the patient should apply immediately for an examination. The duty rests on the gynecologist, the teacher of gynecologic diagnosis, to provide facilities for instruc-

TABLE III.—CORRELATION OF THE HISTOLOGIC AND CLINICAL SIGNS

Group	Macroscopic Appearance	Histologic Development	Grouping of the Extent of the Growth	Symptoms
1	Nodule	Cellular atypia	*Clearly localized growth* Normal mobility of uterus	None
2	Ulcer or papilloma	Invasion of basement membrane	*Doubtfully localized* Impeded mobility of uterus	Contact bleeding
3	Large ulcer or cauliflower growth, with necrosis	Destructive tendencies	*Invasion* of parametrium or regional lymph nodes. Entire tumor mass mobile	Hemorrhage, discharge
4	Crater	Metastasis, local or distant	1. Frozen pelvis with absolute *fixation* of tumor 2. Local *dissemination* to vagina, bladder, or rectum 3. Distant metastases.	Hemorrhage, discharge, pain

tion in diagnosis to the general practitioner in his clinic, so that he may be taught to recognize a pathologic cervix. If the practitioner is well trained in diagnosis he may institute necessary procedures. If he cannot make the diagnosis, he should know that immediate, expert consultation should be had. Delay for the purpose of observation is an error, if carcinoma must be ruled out. If the beginning stage of cancer were not devoid of symptoms, then the outlook for better end-results of treatment would be encouraging. A cancer causing symptoms has very often passed the stage of curability.

CONCLUSIONS

1. The influence of the radiation dose on the five-year cures has been discussed briefly. It has been shown that an increase in the dose, due to perfection in technic, has given better permanent end-results.

2. It is doubtful if the absolute percentage of five-year cures can be improved by the present methods of treatment. Since the relative curability of clearly localized, *i.e.*, beginning, cancers is about 80 per cent, and as the early stage is free from symptoms, the patient cannot be aware of the onset of the cancer. The physician must discover such beginning stages by requesting routine yearly examinations following labor, abortion, and puerperium. When making a first health examination, he should subject every female patient to inspection and palpation and insist on a yearly reexamination thereafter.

3. The macroscopic, microscopic, growth, and symptom characteristics have been discussed and graded. Thereby it is hoped to facilitate very early diagnosis of cervical cancers.

DISCUSSION

Dr. L. R. Sante (St. Louis): It is with some temerity that I attempt to discuss Dr. Schmitz's paper, for he has had wide experience for a long period of time. It is rather gratifying to the radiologist, however, to see the increasingly good results that are attained by him over these various year-periods with the increase in the penetrability of the x-rays used. You know, it seems surprising, but there are to-day large cancer clinics in which x-rays are not used in conjunction with radium treatment. Yet they attempt to evaluate their treatment with radium alone as against the use of radium and x-rays.

Dr. Schmitz's high percentage of cures should be convincing and could hardly be compared to any other method of treatment, surgery included, it seems to me. I think his statistics are quite convincing and I hope they are given widespread publicity among the medical profession.

His high percentage of ultimate cures by radium and x-rays in cases in Groups 2 and 3 that do not come up for consideration at all as surgical risks compares more favorably than the best figures with the surgical method of treatment. Yet we still have to-day from isolated services papers indicating the superiority of operative procedure in carcinoma of the cervix. Oftentimes these statistics are based on inaccurate estimates of results of radiation with radium, without associated x-ray therapy.

It is high time, it seems to me, that the truth concerning the use of radiation be made known and such statistics as Dr. Schmitz has shown should obtain the widest publicity in the entire medical profession.

Dr. Robert E. Fricke (Rochester, Minn.): Dr. Schmitz's five-year results show what can be accomplished by scientific, thorough, painstaking work. His classification is excellent and is based on good anatomic grounds.

I think the one point on which we often differ in statistics is in the classification. Conditions that some of us would call Stage 2 would be called Stage 3 by others, and so forth. I want to call your attention to an important publication which came out in 1929,[1] in which Heyman, of Stockholm, Regaud, of Paris, and Döderlein, of Germany, worked out their five-year results, describing them fully

[1] Cancer Commission: Reports submitted by the Radiological Subcommission. Geneva, Series of League of Nations Publications, 3, Health, 1929, 3. 5, 82 pages.

according to the anatomic classification. They described their Stages 1, 2, 3, and 4 much as Dr. Schmitz has, but, nevertheless, I think that all radiologists in gynecologic work should have this report at hand.

At the Mayo Clinic, Dr. Bowing and I have the report on our desks at all times and try to transpose our cases into the correct stage according to the classification. It is helpful to have a common standard of classification to which all of our cases in any locality may be made to conform.

DR. SCHMITZ (closing): The points I wish to bring out are:

1. The significance of chronic cervicitis as a precursor of carcinoma.

2. Cancer must have existed for some time before it causes symptoms.

3. Routine health inventories, especially of women who have had infections or gone through abortions and labors, to discover pathology, notably nodules or papillomas.

4. If the physician interprets the pathologic cervix correctly and institutes indicated treatment without delay and before symptoms arise, cancer of the cervix will be put under control. Statistics prove that cases treated during this stage show from 75 to 90 per cent permanent cures.

RESULTS OF IRRADIATION IN THE TREATMENT OF OPERABLE OSTEOGENIC SARCOMA OF THE LONG BONES[1]

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UP to 1923, the results following surgical treatment of periosteal or subperiosteal sarcoma, now classified as osteogenic sarcoma, were bad, one reason for this being that the diagnosis was not often made until the disease had reached such an advanced stage that there remained little hope of saving the life of the patient by amputation or other form of treatment. In a review of the statistics of various European clinics, mostly in England and Germany, Butlin (1) found only one three-year recovery in 68 cases of periosteal sarcoma of the femur treated by hip joint or high amputation, and not a single recovery in sarcoma of the humerus. Little improvement in results was noticed until 1920. In 1922, Meyerding (2), of the Mayo Clinic, reported 15 five-year recoveries in a series of 100 cases of sarcoma of the long bones, exclusive of giant-cell tumors, treated by amputation. In many of these cases, amputation was followed by prophylactic treatment with Coley's toxins, and in a number, by irradiation of the chest. An improvement in results was noticed in the European clinics also. In May, 1923, at a Symposium on Bone Sarcoma by the Association of Surgeons of Great Britain and Ireland, held in London, Gask reported 57 cases of sarcoma of the long bones, exclusive of giant-cell tumors, that had been admitted to St. Thomas' Hospital during the period from 1901 to 1921. In 46 cases amputation was performed; 12 patients were alive three years later; 7 were well for more than five years, and one died of metastasis to the skull almost seven years after amputation.

These are exceptionally good results, and yet, when Meyerding read his paper at the meeting of the American College of Surgeons in 1922, Besley, of Chicago, who took part in the discussion, stated that he had amputated the limb for sarcoma of various types in 20 cases at the Cook County Hospital, and that, as far as he had been able

[1]Read before the Radiological Society of North America, at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28–Dec. 1, 1932.

to learn, there had not been a single permanent recovery. He added: "I have performed my last amputation for sarcoma of the long bones." Only a few years later one of the most distinguished professors of pathology in America told me that if he personally had ever had a sarcoma of a long bone he should have an immediate amputation performed regardless of the histologic type of the tumor. Here we have two widely divergent views regarding the best method of treating sarcoma of the long bones. In further proof of this I would cite Crile (3), whose recent study of 7,390 cases of malignancy (of which 160 were bone sarcoma) has led him to the following conclusion: "It is still uncertain whether a primary malignancy of bone should be treated by x-ray or by surgery, but two things are certain—first, if an operation is performed, it should be preceded and followed by x-ray radiation, and second, if the condition is in a limb, amputation should immediately follow radiation, provided the condition is not inoperable." On the other hand, Forssell (4) doubts whether irradiation prior to or after amputation is of any use. Personally I have always been strongly opposed to pre-operative irradiation for sarcoma of the long bones and up to the present time there is little evidence to prove post-operative irradiation is of value.

Nor is a study of the recent literature on the subject very helpful. During the past five years four important books on bone sarcoma have been published, two in France and two in the United States.[2] With the exception of that by Geschickter and Copeland, based on a study of the large amount of material at Johns Hopkins Hospital, these books afford the surgeon little help in choosing the best method of treatment of sarcoma of the long bones.

Twenty years ago the percentage of five-year recoveries following amputation alone varied from 2 to 4 per cent. With increasing ability to interpret the roentgenologic features of the early stages of bone sarcoma, it became possible to make a diagnosis much earlier than was formerly the case. In other words, an earlier recognition of the disease permitted an earlier amputation. This, I believe, explains the improved results reported in the more or less recent statistics, including those of Meyerding and Gask to which I have already referred. Lacking a knowledge of these results, and basing their opinions on the statistics of more than twenty years ago, many surgeons still maintain a pessimistic attitude toward amputation in the treatment of sarcoma of the long bones. This has resulted in a growing trend toward irradiation for all types of bone sarcoma. At the present time I believe the majority of osteogenic sarcomas are being treated by irradiation.

In trying to choose between two or more methods of treating a serious condition that involves not only the limb but the life of the patient, the first essential is a fairly definite idea of the results obtained in a large series of cases treated by various methods. No such rule has been observed in the drift toward irradiation because until recently the essential data for making this choice were lacking. In the great majority of cases I doubt if either the surgeon who refers the patient to the radiologist or the radiologist himself, has any clear idea of the end-results obtained in a large series of sarcomas of the long bones treated by irradiation, and without such knowledge I cannot see how either can give an opinion of much value. The recently published statistics of the Memorial Hospital[3] covering more than two hundred cases of operable malignant sar-

[2]Nové-Josserand, G., and Tavernier, L.: Tumeurs Malignes des Os. Gaston Doin & Cie., Paris, 1927.

Sabrazès, J., Jeanneney, G., and Mathey-Cornat, R.: Les Tumeurs des Os. Masson et Cie., Paris, 1932.

Geschickter, C. F., and Copeland, M. M.: Tumors of Bones. Am. Jour. Cancer, 1931.

Kolodny, A.: Bone Sarcoma. Surg., Gynec. and Obst., April, 1927, Part II.

[3]Ann. Surg., March, 1933.

coma of the long bones treated by primary irradiation (x-rays or radium), I believe furnish sufficient data from which to formulate an opinion as to the relative value of irradiation and amputation in this condition, and it is the purpose of this paper to review these statistics especially as regards osteogenic sarcoma.

In 1916, shortly after the Department of Bone Sarcoma was organized at the Memorial Hospital, we began a study of the question of the value of irradiation in the treatment of bone tumors, including both the malignant osteogenic and the benign giant-cell types. We had at our command an adequate amount of radium as well as the most approved high and low voltage x-ray equipment. The late Dr. Janeway, Dr. Quick, and, since 1921, Dr. Herendeen, Dr. Duffy, and Dr. Bradley L. Coley, have been all greatly interested in the problem. Realizing that the results of amputation were far from ideal—although steadily improving with our increasing ability to make an earlier diagnosis—we were willing to give irradiation a fair and prolonged trial. Even if we did not succeed in curing more cases by irradiation than had recovered after amputation, we hoped that a later amputation, after failure to control the disease by irradiation, might show a higher percentage of five-year recoveries.

After a careful analysis of our results in 1928 we were forced to conclude that the opinion expressed by Janeway, as well as by Pinch, of London, that osteogenic sarcoma is too highly resistant to irradiation to justify the latter's employment in these cases, was correct. This opinion was apparently reached by Ewing also, who, at the International Cancer Congress in London, in 1928, stated:

"When the signs point to a true osteogenic sarcoma of medullary and subperiosteal, sclerosing, or telangiectatic type, the best treatment is probably immediate amputation, preceded if necessary by a biopsy at the same time . . . with these cases, radiation seems to have accomplished very little."

Owing to certain patients' refusal to submit to an amputation we have continued to use irradiation in a considerable number of cases of operable osteogenic sarcoma observed since 1928, but this increased experience has not caused us to alter our opinion. We still believe that the best method of treating osteogenic sarcoma of the long bones is amputation (without pre-operative irradiation) as soon as the diagnosis is established, with, most important of all, a prolonged course of Coley's toxins as a prophylactic measure, after amputation. I have long advocated this in all of our cases as a routine.

As regards a brief preliminary course (one month) of irradiation before amputation, meanwhile submitting the roentgenograms to a number of radiologists for the purpose of establishing the diagnosis, as advised by some, I would say that I cannot commend this practice. Consultations are usually of value in all difficult cases—and there are few fields in medicine or surgery in which an early diagnosis is more difficult than in bone sarcoma—but a multiplicity of opinions is not always an advantage. Bloodgood (5) tells of a surgical colleague who submitted the roentgenograms of a bone tumor to sixteen consultants and received sixteen different opinions. He recalls another who submitted his case to eight consultants; all agreed on an amputation without biopsy, which was performed—the condition proved to be osteomyelitis of the Garré non-suppurative type.

While a few cases can always be cited in which it has been found extremely difficult to make a diagnosis not only from the clinical and roentgenologic evidence but even with the aid of the microscope, these should be recognized as exceptions. In the majority of cases of bone sarcoma it is possible for anyone who has had considerable experience

in this field to make a correct diagnosis, even in the early stages of the disease. In fact, if we wait until the tumor has developed sufficiently for anyone to make a positive diagnosis, we have waited too long, in many instances, to save the life of the patient. Those who have had a large experience in this field know that in certain cases the growth of the tumor is very rapid; a series of roentgenograms taken at various intervals will often show the tumor to have doubled in size in the course of three weeks. This being so, I can see no advantage in running the risk of the disease becoming generalized during the period of irradiation when there is no corresponding advantage to be gained. If the entire tumor, with the limb or the major part of it, is to be removed, why is it not more rational and more logical to remove it as early as possible without waiting a month for irradiation and running the risk of metastases developing? While these may be regarded as theoretic grounds for objecting to pre-operative irradiation, we have far more convincing practical grounds which I shall present.

I repeat that I do not think we are ever justified in waiting four weeks to make a positive diagnosis of osteogenic sarcoma of the long bones. I have had patients who have died within three months of the first appearance of the tumor, and others who have developed extensive pulmonary metastases within two weeks following high voltage x-ray treatment. For example, the following case.

Case 1. A. McK., female, aged 17 years, was admitted to the Memorial Hospital on October 29, 1923. One year previously she had fallen and injured her right knee. In August, 1923, there was increasing pain and swelling of the knee. The clinical diagnosis on admission was that of periosteal sarcoma of the lower end of the femur. From November 2 to November 9, 1923, she had three exposures to x-rays, 15 minutes each. On November 4 she developed a temperature of 102°; this subsided but rose to 101° on November 23, to 103° on November 24, and to 104° on November 25. Symptoms developed which were regarded as pneumonia with pleurisy. On aspirating, several ounces of bloody fluid were evacuated. Roentgenograms taken on December 9, 1923, showed evidence of extensive pulmonary metastasis. Another cycle of roentgentherapy was given from January 3 to January 14, 1924 (four exposures, 60 minutes each). The disease ran a rapid course and proved fatal on February 8, 1924, a little over three months after the patient's admission to the hospital.

If a positive diagnosis cannot be made from a study of the clinical and roentgenologic evidence, then a biopsy should be performed by the surgeon who has been selected to take charge of the future treatment of the case.

Contrary to the opinion of Bloodgood and Dean Lewis, I should never amputate a limb on the strength of a diagnosis made from a frozen section alone. If the tumor contains new bone, as so many osteogenic sarcomas do, then it is impossible to make an accurate diagnosis from a study of the frozen section; one must wait for decalcification of the specimen to take place. I have never seen any bad result from the short delay incident to preparing paraffin sections. According to John B. Murphy, "The surgeon who depends upon frozen sections for a diagnosis in bone tumors of central origin will come to grief."

The cases in which there has been the greatest difficulty in diagnosis and the greatest difference of opinion, both as to the type of tumor and the treatment to be employed, in my experience, have been those involving the upper end of the humerus in children and in young adults. I recall four such cases.

Treatment.—The first point to be considered is, whether or not pre-operative irradiation shall be employed.

Pfahler and Parry (6) claim in a paper entitled "Treatment of Osteogenic Sarcoma

by Means of Irradiation" that preliminary irradiation of bone tumors for three or four weeks, followed by amputation, has given them the best results to date. They add: "Based on Holfelder's observations, it would seem that we may not have waited long enough for the full beneficial effects of irradiation." They advocate a biopsy but only after one month of irradiation by deep roentgen therapy. An analysis of the 57 cases reported therein shows only six sarcomas of the long bones well for a period of five years or more, four of which were treated by amputation in addition to irradiation, and one by excision. The only one treated without surgery had no microscopic confirmation of the diagnosis. Therefore, their results were not obtained "by means of irradiation" alone but by irradiation plus surgery.

While the results of Pfahler and Parry are markedly better than those obtained at the Memorial Hospital by prolonged irradiation, they are no better than, if as good as, those reported by Meyerding, of the Mayo Clinic, and Gask, of St. Thomas' Hospital, London, who employed early amputation without irradiation. In spite of this, Pfahler and Parry, and Holfelder (7) of the Roentgen Institute of the Surgical University Clinic, Frankfort, who is so frequently quoted by Pfahler, agree that irradiation is superior to surgery, and believe it is now the method of choice in the treatment of osteogenic sarcoma. Holfelder advocates prolonged irradiation instead of amputation. In analyzing his series we find that it consists of only 25 cases, nearly one-third of which were giant-cell tumors, and of which only 16 were traced for more than three years. In three of the six classified as clinical cures, there was no histologic confirmation of the diagnosis. Therefore, I regard Holfelder's series as much too small and the period of observation too brief to be of any value in making a comparative study of irradiation and amputation in the treatment of osteogenic sarcoma.

There is one difficult question that has scarcely been touched upon by the advocates of pre-operative irradiation for sarcoma of the long bones, and that is, in the event of marked improvement (and there are many such cases in our own experience), are we to stop at the end of a month's time even if the tumor is much smaller? Apparently most would continue irradiation as long as improvement is observed. Unfortunately our experience at the Memorial Hospital has shown that those osteogenic sarcomas that have responded to such an extent as almost to warrant regarding them as endothelial myelomas, after a few months have suddenly developed metastases to the lungs and other bones. Then, at this late date, amputation has yielded bad results, much worse than has early amputation.

While Bloodgood (5), in 1931, saw no objection to a brief course of irradiation for three or four weeks prior to a biopsy or an amputation, one year later (8) he took a much stronger stand in favor of pre-operative irradiation, as will be seen by the following quotation:

"The deep x-ray therapy is available all over the country so there is no difficulty in giving the patient the benefit of a full trial while the diagnostic survey and consultation are going on. . . . I repeat and emphasize that with our knowledge as it is to-day it is distinctly better to begin the treatment of every bone lesion which in the x-ray is suspicious of malignancy, with a thorough and complete course of irradiation."

Let us examine for a moment Bloodgood's argument. While it is true that "the deep x-ray therapy is available all over the country," it is only fair to point out that but comparatively few radiologists have had a large experience in the treatment of bone sarcoma. A considerable number of serious results from over-irradiation of bone tumors have occurred even in the hands of ex-

perienced radiologists. Bloodgood himself states:

"I have specimens of three limbs in the laboratory in which a bone was the seat of a benign cyst, and prolonged deep x-ray therapy had so destroyed the soft parts or necrosed the bone that amputation was necessary. There are, in addition, five examples of giant-cell tumor in which the introduction of radium into the bone shell after curetting was associated with an osteomyelitis which resulted ultimately in producing great deformity and loss of function or making amputation necessary. These preventable results from irradiation have not all been in the hands of inexperienced radiologists."

A considerable number of similar results have been observed at the Memorial Hospital, and I believe this number would be still further increased if we were to adopt the practice of treating "every bone lesion which in the x-ray is suspicious of malignancy, with a thorough and complete course of irradiation."

Next, what is meant by "a thorough and complete course of irradiation"? It certainly means more than the brief period of three or four weeks while waiting to make a diagnosis, as suggested by Bloodgood in 1931. One is led to believe that he would continue irradiation as long as there was any evidence of improvement. Apparently both the contemplated biopsy and the possible amputation are to be postponed indefinitely. This procedure I believe to be a bad one, and, if generally followed, will almost certainly result in the loss of many lives which otherwise might have been saved by early amputation without preliminary — especially without prolonged—irradiation.

I do not think the danger of prolonged irradiation in osteogenic sarcoma can be too strongly emphasized. I recall two cases of osteogenic sarcoma in which the diagnosis was made in the early stages, and in both of which irradiation was advised by Bloodgood. The first was a sarcoma of the tibia in a girl who, before coming to me, had received four months' intensive irradiation without apparent effect in controlling the growth of the tumor or in alleviating pain. Although I performed an immediate amputation, following this with prolonged toxin treatment, the patient developed metastases and died within six months. The second patient was a young man with a sarcoma of the lower end of the femur that had developed shortly after a severe local trauma. A correct and early diagnosis of osteogenic sarcoma had been made from the clinical and roentgenologic evidence alone. Irradiation was advised. The pain was promptly relieved, and marked improvement was noticed in the local condition. On these grounds it was deemed wiser to continue the irradiation instead of performing an amputation at the end of a few weeks. The treatment was kept up for nearly a year, at the end of which time the patient was told he could resume his work. Shortly thereafter, he was referred to our clinic. While there was scarcely any noticeable enlargement of the femur, it was thought best to perform a biopsy. This was done and the tumor proved to be an osteogenic sarcoma. An immediate amputation was performed by Dr. Bradley L. Coley, followed by prophylactic toxin treatment. In spite of this, the patient developed metastases to the clavicle and other bones within three months, and later to the lungs, and died within six months.

In both of these cases I believe the chances of saving the patient's life would have been greater had an early amputation been performed without preliminary prolonged irradiation. A third case, admitted to the Hospital for Ruptured and Crippled in 1930, still further supports this opinion. A male adult, whose family history was negative, complained of pain and swelling in the mid-femur over a period of nine months. He had been admitted to one of the best hospitals of New York where a correct diag-

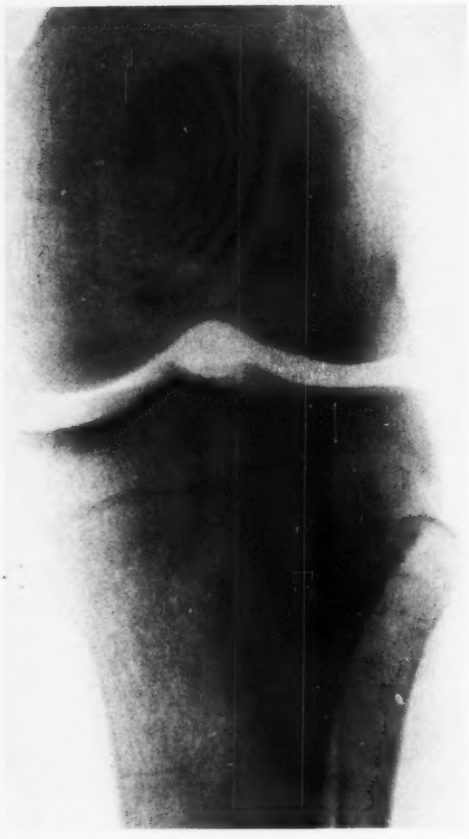

Fig. 1. Osteogenic sarcoma of tibia treated with x-rays for three months; no improvement. Amputation by Dr. B. L. Coley, July 20, 1927. Pulmonary metastasis; death.

nosis of osteogenic sarcoma had been made from the clinical and roentgenologic evidence supported by a biopsy. High voltage roentgen therapy was given over a period of eight months. The tumor gradually increased in size and the pain persisted; in addition, the biopsy wound remained unhealed. When I first saw the patient he had a tumor involving two-thirds of the shaft of the femur and extending so high up that a hip-joint amputation was impossible. A large fungating mass occupied the whole anterior surface of the thigh from which exuded a sanguino-purulent discharge. The patient had had several small hemorrhages which had increased in frequency and severity. He received nothing but palliative treatment while under my care, and died within a few weeks. The lesson to be learned from this case is most important: An autopsy was performed which failed to reveal evidence of metastases in any other part of the body. In other words, had an amputation been performed at an early date or even before the condition had become inoperable, it is almost certain that the patient would have been alive to-day.

I mention these cases to show how widely prevalent has become the practice of turning cases of osteogenic sarcoma of the long bones over to the radiologist for treatment. Hitherto there was a reasonable excuse for this practice inasmuch as there were no published statistics on the results of irradiation in a large series of osteogenic sarcoma.

It may be argued that improvement in the technic of administering radium and roentgen ray may lead to better results. Granting this, I believe there will always be a sufficient number of cases of osteogenic sarcoma that refuse amputation or in which amputation is contra-indicated for various reasons, to furnish ample material for further research with irradiation; but I do not believe we are any longer justified in substituting irradiation for amputation in the early operable osteogenic sarcomas of the long bones, thereby depriving the patient of a considerable chance of a permanent cure.

That this opinion is based upon more than a personal experience is shown by the following case. A short time ago I wrote to Dr. B. C. Crowell, the Registrar of the Bone Sarcoma Registry of the American College of Surgeons, asking him how many of the registered osteogenic sarcomas treated by irradiation had remained well for five years or more. His reply was that there were two, only one of which was a sarcoma of a long bone. It was associated with a football injury. There had been no microscopic con-

firmation of the diagnosis, and in the opinion of Dr. Ewing, the condition might well be one of myositis ossificans. The other case, registered by Evans and Leucutia, was an inoperable sarcoma of the ilium of the osteogenic type. It was classified as an osteogenic sarcoma by the Registry Committee but the fact that it was called a "round-cell" tumor with apparently no new bone formation, makes it possible to consider a diagnosis of endothelial myeloma, or Ewing's sarcoma.

The present Bone Sarcoma Registry of the American College of Surgeons was founded by Dr. E. A. Codman in 1920. It was the hope of the founder, as well as of those interested in this field, that a careful study and analysis of this vast collection of material, including the clinical, roentgenologic, and microscopic data, would lead to clearer understanding of the various types of bone sarcoma, and would prove an invaluable aid in the selection of the best method of treatment, thus bringing about an improvement in the almost hopeless prognosis of osteogenic sarcoma. That this hope has not been fulfilled has been demonstrated on several occasions, most strikingly, in my opinion, by the exhaustive study of the Bone Registry cases made by Kolodny (9), in 1927, and by the more recent, brief report of Bartlett (10). In his chapter on the treatment of osteogenic sarcoma (p. 107) Kolodny states:

"In bone sarcoma as in other malignant tumors the question of the therapy is still awaiting its answer. It is a strange fact that with our knowledge of minute details of the histopathology of bone tumors the progress along the practical therapeutic road is almost in the same stage that it was in some fifty years ago. As a rule, malignant bone tumors are fatal and we know of no therapeutic method to prevent death from this disease."

Three years later Bartlett, in analyzing 125 registered cases which had been followed for five years after the last treatment,

Fig. 2. Same case as shown in Figure 1 after three months' irradiation.

found 11 cases of endothelial myeloma and 31 of osteogenic sarcoma that were classified as five-year cures. Of the 31 osteogenic sarcomas, 29 were of the long bones. Amputation was performed in all but one case. This, Bartlett has classified as "fibro (?) sarcoma (atypical)," treated by "exploration, excision, toxins, and radium." As this happened to be one of my own cases, a few comments may be permitted. In the first place, only an exploratory biopsy was performed; there was no excision—merely a small piece of tissue was removed for microscopic examination. The tumor involved

nearly one-half of the tibia. Amputation had been advised by almost all who had seen the case. A positive diagnosis of typical periosteal osteogenic sarcoma was made by Ewing, and the diagnosis of the Committee of the Bone Sarcoma Registry was that of osteogenic sarcoma. An unusual feature of this case was the presence of extensive metastases in the inguinal, iliac, and femoral glands (diagnosis confirmed microscopically). Under Coley's toxins and irradiation (radium pack) the patient made a complete recovery, and is in excellent health, with a useful limb, at the present time—16½ years later (see Case 2 below). Seven of the 31 five-year cures of osteogenic sarcoma tabulated by Bartlett are my own cases. It is stated in error that all have had amputation. One, already referred to, recovered under toxins and irradiation, and the limb was saved.

Bartlett continues:

"In reviewing the microscopic pathology one is struck by the preponderance of chondromatous tissue, and when one looks at each case as a whole he is further struck by the fact that none of the cured cases were truly typical of any of the known forms of osteogenic sarcoma. This group of thirty-one cures, therefore, probably does not indicate the real situation and for the present we must consider the clinically typical case of osteogenic sarcoma as incurable."

I do not believe that the presence of cartilage or chondromatous elements in the tumor indicates a low degree of malignancy. In the opinion of Geschickter, "primary myxochondrosarcoma is extremely malignant: of 77 cases of this type there are only from 3 to 5 per cent five-year cures after amputation."

For some reason not known to me, Bartlett chooses to regard these 31 five-year recoveries as not true osteogenic sarcomas but as "atypical" cases. The question is, what does he mean by a "typical osteogenic sarcoma"? This I believe is a good example of what takes place when the refinement of histologic classification is permitted to run wild and to create a much different impression from that which the facts warrant. In each of these 31 cases the diagnosis was confirmed by the Committee of the Bone Sarcoma Registry, all members of which are unusually well-versed in the diagnosis of bone tumors. If such a committee is unable to make a correct diagnosis of osteogenic sarcoma, then we might well regard the question as hopeless. Frankly speaking, I myself, after a long clinical and histologic study of bone tumors, extending over a period of more than forty years, am unable to say exactly what is meant by a "typical osteogenic sarcoma." While some writers apparently regard a typical osteogenic sarcoma as one associated with a large amount of new bone formation radiating at right-angles to the shaft of the bone, Kolodny has shown that this group represents only about 18 per cent of all cases of osteogenic sarcoma. While there is often a marked variation in the degree of malignancy, our ability to diagnose these variations depends much more upon the clinical than upon the histologic evidence. According to Kolodny, the attempts of pathologists to form a prognosis on a tumor from its pathologic and morphologic features alone has nowhere failed more than in bone tumors. To make such a broad statement as Bartlett's that "we must consider the clinically typical case of osteogenic sarcoma as incurable," is not, in my opinion, in accord with the facts. It is certainly not supported by the end-results obtained at the Memorial Hospital, the Hospital for Ruptured and Crippled, Johns Hopkins Hospital, or the Bone Registry. Our own series contains no less than 24 cases of osteogenic sarcoma, as typical as one could hope to find, the diagnosis in most cases having been confirmed by Ewing, and in many by the committee of the Bone Sarcoma Registry. All show definite clinical evidence of malig-

nancy, and all were well from five to twenty-eight years after amputation. With results such as these, I cannot understand how Bartlett can make the following statement:

"We have learned to allow our patients who are suffering with malignant bone disease to die whole under the comforting and pain-relieving effects of x-ray and morphine, and we have learned to carefully preserve the limbs affected with non-malignant disease, thus saving their owners from a life of mutilation, deformity, and disability."

I do not believe that a large number of limbs have been amputated for supposed malignant sarcoma, which later proved to be the site of a benign lesion. Personally, I have never had such a case.

Such a statement as the one quoted above, if accepted, cannot but do great harm in dissuading patients from submitting to an amputation which, if followed by post-operative treatment by Coley's toxins, offers a considerable chance, at least 30 per cent, of saving their lives. Bartlett's list of 31 five-year recoveries from osteogenic sarcoma by no means represents the entire number of "cured osteogenic sarcomas of the long bones" in the Bone Sarcoma Registry, since it includes only six cases registered under my name and omits ten additional five-year recoveries of osteogenic sarcoma of our Memorial Hospital series that had already been registered below the last serial number mentioned in Bartlett's list. Our entire list of five-year cures of sarcoma of the long bones contains 33 cases of osteogenic sarcoma and 23 cases of endothelial myeloma.

Inasmuch as the following case (Reg. No. 183) for a long time was the only registered osteogenic sarcoma in which the limb was saved, and the only osteogenic sarcoma with metastases that had been cured by any method of treatment, a brief history may be of interest.

Case 2. *Periosteal osteogenic sarcoma involving one-half of the shaft of the tibia, with extensive metastases to the groin and iliac fossa. Treated by Coley's toxins and irradiation; limb saved; patient well more than fifteen years later.*—C. H. S., male, aged 39 years, was referred to me by Dr. John H. Gibbon, of Philadelphia, in the latter part of April, 1917, with a history of a rapidly growing tumor of the shaft of the left tibia of six weeks' duration. It was regarded by Dr. Gibbon and several other surgeons as a periosteal sarcoma. While I agreed with this diagnosis, yet in order to have it confirmed microscopically, I removed a small piece of the tumor and submitted it to Dr. Ewing, who pronounced it a highly malignant osteogenic sarcoma. In an attempt to save the limb, the following conservative measures were adopted: Injections of Coley's toxins were given in conjunction with irradiation (the radium pack, 46,720 millicurie-hours, was applied over the tibia from May 1 to July 19). The toxins were resumed at home by the patient's family physician, Dr. R. G. Gamble, of Philadelphia. In the middle of August, the patient asked permission to go to the seashore for a month, and as physical examination at this time showed no evidence of the disease remaining, it was thought safe to discontinue the treatment for a few weeks. On his return in the early part of October, examination showed extensive metastases in the inguinal, femoral, and iliac glands, some of which were an inch or more in diameter. Notwithstanding the hopeless prognosis, I decided to give the patient a further trial of treatment. The radium pack was applied over the glands of the groin in October (18,000 mc.-hrs.), in November (17,270 mc.-hrs.), and in December (12,000 mc.-hrs.). At the same time the toxins were resumed and kept up with occasional intervals of rest for two and a half years, in doses not sufficient to interfere with the patient's routine of life. All evidence of the disease disappeared, and the patient is alive with a useful limb at the present time, sixteen years later.

The result obtained in this case illustrates the importance of continuing the treatment over a long period of time.

Case 3. *Osteogenic sarcoma (No. 100, Bone Registry) of the lower end of the femur treated with prolonged irradiation (radium)*

Fig. 3. Osteogenic fibrosarcoma of humerus. It was impossible to make a diagnosis for nearly four years in spite of repeated biopsies and roentgenograms. Treated with prolonged irradiation; amputation; death from metastases a few months later.

and toxins; later, amputation followed by prolonged prophylactic toxin treatment. Patient was well for eleven years and then died of metastases.—Mrs. W. P., aged 30 years, complained of a stiff knee and loss of weight over a period of one year, accompanied by gradual increase in the size of the joint. She had been advised by Dr. George E. Brewer and Dr. George D. Stewart, of New York, to have an immediate amputation, but this was not performed at the time. She entered Dr. Howard Kelly's Hospital in Baltimore, where, under the care of Dr. C. F. Burnam, she received 125,761 mc.-hrs. of radium betwen Oct. 23, 1916, and Jan. 11, 1917. She then returned to Dr. J. M. T. Finney, who performed an exploratory operation and referred the patient to me for toxin treatment. A diagnosis of periosteal sarcoma had been made.

For five months she was treated with injections of Coley's toxins supplemented by one application of the radium pack (7,200 mc.-hrs.). Little improvement was noticed, and I finally performed an amputation on July 6, 1917. Microscopic report by Dr. Ewing: Periosteal osteogenic sarcoma of the sclerosing type.

Under prolonged prophylactic treatment with Coley's toxins the patient remained well for nine years. She then developed a hard nodule, the size of a small marble, in the labium major. Under novocaine I removed it and found it to be a bony tumor that, without decalcification, could not be cut. Sections showed unusual conditions interpreted in different ways by several pathologists. In the opinion of Dr. Jeffries, pathologist of the Hospital for Ruptured and Crippled, the present condition had some connection with the original sarcoma of the femur. In the opinion of Dr. Ewing and Dr. Symmers, the sections showed no evidence of malignancy.

In July, 1928, the patient complained of pain in the mid-scapular region. Roentgen-ray examination in early August showed a degenerative process at the junction of the fourth rib and spine, apparently involving both, with some new bone formation as well, the condition being regarded as metastases from the original tumor. Examination at the time of the patient's admission to the hospital, two weeks later, showed a definitely palpable tumor of the scapular region apparently originating in the ribs. In spite of intensive radium and toxin treatment, the disease steadily progressed. At the end of two months, a roentgenogram of the chest showed definite evidence of pulmonary metastasis. All treatment, other than symptomatic, was discontinued and the patient died shortly thereafter.

In this case I believe the long postponement of a recurrence of the disease was due to the inhibitory action of the toxins. The diagnosis of the Bone Sarcoma Registry was that of osteogenic sarcoma. By some error this case has been registered under the name of Bloodgood (No. 100).

Case 4. *Periosteal osteogenic sarcoma (Bone Sarcoma Registry No. 1352) of the*

upper end of the humerus treated by brief preliminary irradiation (x-rays for one week), amputation, and post-operative toxin treatment. Patient was well seven and one-half years later.—K. C., female, aged 34 years, was admitted to the Memorial Hospital on Aug. 22, 1925, with a history of having noticed pain in both arms for a period of six months. The condition was regarded as rheumatic. Three weeks before admission, the right arm became swollen and increasingly painful. Physical examination revealed a hard, irregular, fixed, tender, bony tumor extending all about the shaft of the upper third of the right humerus and the head of the humerus. The x-ray report stated: "A typical osteogenic sarcoma is seen involving the upper third of the right humerus. No evidence of metastasis in the films of the lungs." Treatment consisted of pre-operative roentgentherapy, one full erythema dose through each of two portals, given from Aug. 25 to 28, 1925. Shoulder-joint disarticulation performed on Sept. 16, 1925. Coley's toxins were begun immediately after the amputation and continued for four or five months at home by the patient's family physician.

Microscopic examination by Dr. Ewing: "Osteogenic sarcoma, very cellular, much new, rather typical bone formation." This diagnosis was confirmed by the Bone Sarcoma Registry Committee.

In view of the statement frequently made that there is no record of a metastasizing osteogenic sarcoma originating in an old osteitis fibrosa cystica, the following case is of interest (see Figs. 5 and 6). It is the third of its kind that has been observed at the Memorial Hospital.

Case 5. *Osteitis fibrosa cystica treated by irradiation; amputation nine years later. Microscopic diagnosis: Osteogenic sarcoma. Metastasis to lungs; death.*—M. G., female, aged 13 years, was admitted to the Memorial Hospital on the service of Dr. Quick on April 17, 1919. Six years previously the patient had suddenly felt pain in the upper part of the right tibia, and a swelling had developed almost immediately thereafter. The pain subsided in a few days but the swelling remained. There was no further trouble until April, 1919, when the patient had a similar attack of sudden severe pain associated with swelling.

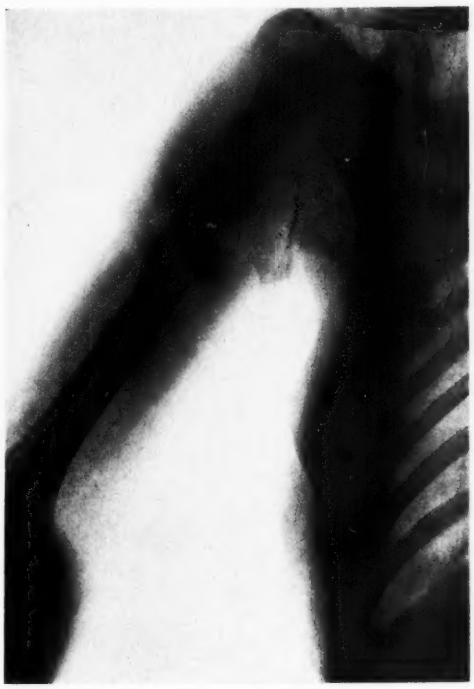

Fig. 4. Same case as shown in Figure 3, three years later.

Physical examination on admission showed a swelling of the anterior and upper portion of the right tibia, measuring 9×5 inches. There was some tenderness on deep pressure. A clinical diagnosis of benign osteosarcoma was made. Roentgenological diagnosis was osteitis fibrosa cystica. A course of roentgen-ray treatment was given.

Follow-up notes stated as follows: "Condition improved as shown by lessening of the size of the areas involved and increased amount of calcification" (March 18, 1920). "Very little change noted" (June 22, 1927). "Definite increase in the pathologic condition over the upper part of the tibia" (Aug. 18, 1927). "Radium pack treatment, 14,000 mc.-hrs." (Aug. 22, 1927). "Radium pack treatment, 12,000 mc.-hrs." (November, 1927).

The patient was shown at the Memorial

Fig. 5. (June, 1919.) Typical osteitis fibrosa cystica treated by irradiation. Amputation nine years later. Microscopical diagnosis: osteogenic sarcoma. Pulmonary metastases; death.

Hospital staff-conference in the latter part of January, 1928, and an amputation was advised. This was performed by Dr. Quick on Feb. 2, 1928. A specimen was examined microscopically by Dr. Ewing, whose diagnosis was that of osteogenic sarcoma with large polyhedral cells. The patient developed pulmonary metastasis shortly thereafter, and died.

Periosteal Fibrosarcoma. — Inasmuch as the number of cases of osteogenic sarcoma that have shown marked and continued improvement from irradiation alone or from toxins and irradiation is very small, it might be well to study these cases more carefully and try to find out if they have anything in common which might help us in deciding on the advisability of substituting conservative treatment for amputation in certain cases of osteogenic sarcoma.

At the Memorial Hospital we have had four cases which have not only shown marked improvement under toxins and irradiation, but in which the tumors have apparently disappeared and the patients have remained well from two to three years. A brief report of these cases may be of interest.

Case 6. Male, aged 47 years, was admitted to the Memorial Hospital on Aug. 6, 1930, for a tumor of the tibia. The microscopic report on the biopsy specimen was fibrosarcoma. There was a history of "rheumatic pain" in the right tibia for fifteen or twenty years. In the Summer of 1930 an exploratory operation was performed at the Sydenham Hospital, and a microscopic diagnosis of osteogenic sarcoma was made, later confirmed by Dr. Ewing. Roentgen-ray examination showed an area of bone destruction in the upper third of the tibia, breaking through the cortex but not infiltrating the soft parts. Erythema doses of radium in three fields were given. While at the Memorial Hospital the patient received 50,000 mc.-hrs. of radium in the form of an element pack applied by Dr. J. J. Duffy between July 31, 1930, and Aug. 31, 1930. In September treatment with Coley's toxins was begun, 15 doses (3 a week), five being injected intramuscularly and the rest intravenously. The swelling, which was never very marked, slowly diminished in size until it had entirely disappeared. The patient is in good condition at the present time, two and one-half years later.

In this case, the clinical, roentgenologic, and pathologic evidence all showed that we were dealing with a slowly developing fibrosarcoma of moderate malignancy, a type that may well be treated conservatively, that is, by irradiation and Coley's toxins, instead of by immediate amputation. The same may

be said of the following case, also, in which the roentgenogram showed no evidence whatever of bone involvement. Evidently the tumor started either in the periosteum or the fascia, was attached to the periosteum, and never really invaded the cancellous portion of the bone. The pathologic report was of special value in helping to determine the type of treatment to be employed.

Case 7. Female, aged 36 years, was admitted to the Memorial Hospital on May 23, 1930, with a history of having first noticed a firm mass in the upper and middle third of the right humerus on the anterior side 14 months previously. It was only moderately tender and not painful. In January, 1930, a biopsy was performed by Dr. Dickinson, of Christ Hospital, New Jersey, and the specimen, submitted to Dr. Ewing, was pronounced a fibrosarcoma. Physical examination on her admission to the Memorial Hospital showed a recent scar, 6 cm. long, in the middle and upper third of the right arm. Beneath the scar, and extending several centimeters in either direction, was a firm, slightly movable swelling; the overlying skin was attached. On deep palpation, one gathered the impression of a band of firm fibrous tissue encircling the humerus, which itself was not apparently enlarged.

Treatment.—On May 19, 1930, four platinum needles containing 146 mc. of radium were inserted in the tumor (total dose 1,314 mc.-hrs.), and again on May 30 (total dose 1,281 mc.-hrs.). Between May 10, 1930, and May 14, 1930, the radium element pack was applied posteriorly and anteriorly (total dose 40,000 mc.-hrs.). In addition, on May 6, the patient received one 15-minute exposure of high voltage roentgen ray.

Examination on July 23, 1930, showed evidence of regression. By October, 1931, the local condition was nearly normal. By November, 1932 (two and one-half years after admission), there was no evidence of the tumor remaining, and there was excellent function of the arm in all directions. The pa-

Fig. 6. Same case as shown in Figure 5, in January, 1928, or nine years later, just before amputation was performed.

tient still remains well at the present time, nearly three years after admission.[4]

Case 8. A. F., female, aged 40 years, noticed pain and swelling following a fall in April, 1929, when she fractured her right humerus and scapula. Five months later an operation was performed at the Troy Hospital and the patient was then referred to me. Examination on her admission to the Hospital for Ruptured and Crippled showed considerable atrophy and weakness of the right arm below the elbow, swelling at the middle third, and contracture of the fourth and fifth fingers of the right hand. A provisional diagnosis of osteogenic sarcoma was made.

Treatment was with Coley's toxins and irradiation. From October 12 to October 24 she received 16,000 mc.-hrs. of radium in the form of a pack; on November 20, 7,000 mc.-hrs., and on December 20, another 7,000 mc.-hours. Coley's toxins were given in increasing doses over a period of six months.

Microscopic report by Dr. Ewing was osteogenic fibrosarcoma, a diagnosis in which the Bone Sarcoma Registry committee concurred but which the latter, about a year later, revised to ossifying hematoma. The patient remains in excellent condition at the present time, four years later.

In this case the roentgenographic report, made by Dr. R. Lewis, of the Hospital for Ruptured and Crippled, on December 21, 1929, is of interest: "The x-rays of the right arm suggest that there is a tumor of the soft tissues which has formed a ring of calcium on its surface and which has caused a loss of bone substance from the shaft of the humerus due to pressure upon the bone and not due to invasion."

Case 9. T. LeP., female, aged 19 years, was admitted to the Memorial Hospital in December, 1929, with a history of persistent but not severe pain in the right knee for two months, and swelling at the same site for one month.

X-ray Report (December 14, 1929).—Films of the right tibia faintly revealed slight changes in the external tuberosity, head of tibia. Diagnosis: osteogenic sarcoma. A short course of irradiation (roentgen ray) was given, and on March 25, 1930, a biopsy was performed by Dr. Bradley L. Coley.

Microscopic Report.—Osteogenic sarcoma. Small foci of cellular tumor, rather radiosensitive. Considerable osteoid stroma, with calcific deposit (not bone). Radiation thrombosis of vessels.

Further irradiation in the form of the radium pack (32,000 mc.-hrs.) was applied in early April; in addition, Coley's toxins were given intravenously in gradually increasing doses. The patient was discharged on May 1, 1930, with the following note: "Case reviewed with Dr. Ewing, who believes it safe to await developments rather than proceed with amputation. Patient in good general condition; has fine flexion of knee and almost complete extension; no pain; practically no swelling." Examination by Dr. Bradley L. Coley on May 28, 1930, showed there was no increase in the size of the knee at the level of the tumor. Palpation revealed no apparent growth. The patient was able to flex and extend her knee within normal limits. She had no pain and had gained ten pounds in weight in the previous three weeks.

X-ray Report (May 3, 1931).—The process in the upper end of the tibia showed evidence of definite improvement and bone regeneration when compared with previous films. There was no evidence of pulmonary metastasis.

In February, 1933 (or three years later), the patient was shown at the weekly conference of the Memorial Hospital staff, at which time she was in excellent physical condition.[5]

Medullary Central Fibrosarcoma of the Tibia.—Case 10. H. F., male, aged 21 years, was admitted to the Memorial Hospital on September 2, 1931, with a negative family history. He stated that on June 18, 1931, less than three months prior to his admission, he had struck his right shin against a barrel. However, a roentgenogram taken a few days

[4]The total depth-tissue dosage for the element pack, roentgen ray, and platinum needles was 540 per cent surface erythema dose.

[5]The patient remained well until Aug. 1, 1933, nearly four years, when she received a blow over the exact site of the old sarcoma. Within a week signs of activity developed and by Aug. 24 there was a well marked recurrence. Amputation was advised.

later showed a central osteolytic tumor of the tibia occupying two different areas several inches apart; so that the injury, apparently, had no causal relationship with the development of the tumor. A biopsy was performed by Dr. T. Wallace Davis at the Hospital for Ruptured and Crippled on August 5, 1931. The sections were examined microscopically by Dr. Ewing, who reported: "Low grade, slowly growing fibrosarcoma of medullary origin. Not very malignant or likely to produce metastases." Under roentgen therapy (four exposures, ten minutes each between September 2 and 11) the patient showed marked improvement and is still well at the present time, one and one-half years later.

The results obtained in the foregoing cases (Nos. 6 to 10) justify, I believe, the employment of conservative treatment (irradiation and Coley's toxins) in this comparatively small group of so-called periosteal fibrosarcoma of the long bones. This type is characterized by little or no new bone formation, and with little involvement of the cancellous portion of bone. The roentgenogram furnishes the best guide to treatment in revealing the absence of new bone and the slight invasion of the cortex. Even in endothelial myeloma, a type of bone sarcoma that is known to be radiosensitive, we have found that in those rare cases in which considerable new bone is present, the disease is highly resistant to both irradiation and Coley's toxins.

Results Obtained in Memorial Hospital Series.[6]—A brief analysis of 168 cases of primary operable osteogenic sarcoma of the long bones treated by irradiation, with or without surgery, and including 39 cases in which Coley's toxins were used, shows the following:

Method Employed	Cases
Roentgen ray	84
Roentgen ray and radium	10
Radium (element pack in 30 cases)	35
Irradiation and Coley's toxins	39
	168

[6]In 10 cases the x-ray treatment had been carried out at other hospitals before the patient came under my observation.

Of the 84 cases treated by the roentgen ray, the only five-year cures occurred in two cases in which amputation was performed after irradiation, and in one case treated by resection following by irradiation.

Of the 10 cases treated by roentgen ray and radium, five-year cures occurred in two cases in which amputation was performed after irradiation.

Of the 35 cases treated by radium alone, the only five-year cure occurred in a case in which amputation was performed after irradiation, and in one case treated by resection and irradiation.

In other words, of 129 cases of osteogenic sarcoma treated by irradiation, there were no five-year cures obtained without amputation or resection; there were 7 five-year cures (or 5.42 per cent) with amputation or resection.

The tumors were situated as follows:

	Cases	Five-year Recoveries
Femur	53	3
Humerus	35	4
Tibia	24	0
Fibula	7	0
Radius and ulna	5	0
Metatarsal	1	0
Metacarpal	1	0
Tarsus (not long bone)	3	0
	129	7

Of the 39 cases treated by irradiation and Coley's toxins, there were four five-year cures obtained without amputation, and two with amputation. Three other cases in which the limb was saved have remained well from two to four and one-half years. One of the five-year cures without amputation was an extensive tumor of the humerus treated with irradiation and toxins over a period of one year. While the Bone Sarcoma Registry Committee at first classified it as an osteogenic sarcoma, five years later they revised their diagnosis to that of giant-cell tumor. Excluding this case, we have five five-year cures in a group of 39 cases (13.05 per cent).

Of the total number of 168 cases treated by irradiation, 102 went on to amputation.

	Cases
Femur	45
Humerus	19
Tibia	27
Fibula	8
Radius	1
Metatarsal	1
Metacarpal	1
	102

In nearly every case irradiation was given over a long period of time; that is, at least several months, or until it became evident that the disease could not be controlled or until metastases developed.

We have another group of 46 cases of operable osteogenic sarcoma of the long bones treated by amputation followed by post-operative toxin treatment *without* prolonged pre-operative irradiation. In this group, 14 (30.43 per cent) have remained well for five years or more.

A study of these statistics shows that while the results obtained by prolonged irradiation and Coley's toxins are a little better than those obtained by irradiation without toxins, they are decidedly inferior to the results obtained by early amputation, without preliminary irradiation, followed by prophylactic toxin treatment.

Five-year Recoveries.—Inasmuch as the number of cases of periosteal sarcoma of the femur well five years after disarticulation or high amputation has proved exceedingly small, and the number of five-year recoveries of sarcoma of the humerus almost *nil*, the results noted in our series should be of interest. (For more details see *Annals of Surgery*, March, 1933.) We have 24 cases of sarcoma of the femur that have remained well for five years; 13 were of the osteogenic, and 11 of the endothelial myeloma type. All of the 13 osteogenic sarcomas were of the periosteal or subperiosteal (older classification) type, a type in which Butlin found only one three-year recovery in 68 cases treated by disarticulation or high amputation. In every one of these 13 cases the diagnosis was confirmed by microscopic examination by leading pathologists. The method of treatment employed was amputation plus Coley's toxins in 10 cases (well from 8 to 27 years), and amputation after prolonged irradiation in three cases (well from 5 to 12 years).

Of the 11 endothelial myelomas of the femur well over five years, two were treated by amputation plus Coley's toxins, six by Coley's toxins alone, and three by toxins and irradiation. In six cases the limb was saved: by toxins and irradiation in two, and by toxins alone in four cases. Six were inoperable and two had extensive metastases at the time treatment was begun.

A study of our humerus cases proves even more interesting, especially in view of Bloodgood's statement that he knew of no case of sarcoma of the humerus above the middle third cured by amputation, and in view of the total absence of cures in the records of the English clinics. Of nine five-year recoveries of sarcoma of the humerus, seven were of the osteogenic and two of the endothelial myeloma type. A microscopic examination confirmed the diagnosis in the seven cases of osteogenic sarcoma.

BRIEF SYNOPSIS OF FIVE-YEAR RECOVERIES OF SARCOMA OF HUMERUS

1. Rapidly growing osteogenic sarcoma starting a little above the middle of the humerus following a recent fracture; practically disappeared under Coley's toxins alone; pathologic fracture united; recurrence near upper portion; amputation at shoulder joint; metastasis in pectoral region; incomplete operation followed by Coley's toxins. Patient well eight years and then died of pulmonary metastasis.

2. Telangiectatic sarcoma of middle and upper thirds of humerus treated for four months with the roentgen ray, then amputation. Patient well nine years later.[7]

[7] In 1922, Dr. Ewing stated that there was no record of a cure of telangiectatic sarcoma by any method of treatment.

3. Osteogenic sarcoma of upper end of humerus; amputation followed by prolonged treatment with Coley's toxins. Patient well eight years later.

4. Osteogenic sarcoma of upper end of humerus. Patient seen in consultation with Dr. J. Bapst Blake in 1898, and treated under my direction; exploratory operation; condition believed to be beyond amputation. Diagnosis of osteosarcoma confirmed by Dr. Mallory, Professor of Pathology, Harvard Medical School. Recovered under Coley's toxins alone. Remained well for 24 years and then died of spinal metastasis.

5. Periosteal osteogenic spindle-cell sarcoma of humerus. Patient of Dr. John H. Gibbon. Treated under my direction with toxins and x-rays. In excellent condition when last traced, 17 years later.

6. Periosteal osteogenic sarcoma of humerus, upper end; resection by Dr. J. M. Hitzrot. Patient referred to Memorial Hospital for after-treatment; radium pack applied by Dr. Janeway and myself. Patient well 12 years later.

7. Periosteal spindle-cell osteogenic sarcoma of upper end of humerus, with very little involvement of the cancellous bone. Roentgen-ray treatment followed by resection. Patient well 10 years later.

Cases 8 and 9, both endothelial myelomas, both well 10 years later.

At the present time we have 56 five-year recoveries of sarcoma of the long bones, 33 of the osteogenic and 23 of the endothelial myeloma type.

SUMMARY

In the 33 cases of osteogenic sarcoma of the long bones, well five years, the toxins were used in all but eight cases; the treatment is summarized as follows:

Amputation alone: one case.

Amputation, followed by Coley's toxins: 18 cases.

Toxins alone: 2 cases.

Toxins and radiation: 4 cases. The limb was saved in these six toxin cases.

One other case, periosteal sarcoma of finger; diagnosis confirmed by Welch and Ewing; excision of tumor only, with prolonged toxins. Patient was well for 20 years.

Irradiation alone: no cases.

Prolonged irradiation, followed by amputation: 5 cases.

Irradiation (x-ray), followed by resection of upper end of humerus: one case, well for 10 years.

Resection of upper end of humerus, followed by radium treatment: one case, well for 10 years.

In addition to the 33 five-year cures of osteogenic sarcoma of the long bones, I have had 11 cases of five-year cures of flat bones (well for from 8 to 32 years).

Toxins alone: 5 cases.

Toxins and irradiation: 5 cases.

One periosteal sarcoma of the mastoid: toxins and three x-ray treatments, after four operations failed to control disease: well 10 years.

All of these cases were quite inoperable at the time they came under my care.

CONCLUSIONS

Shall we conclude that irradiation has no place in the treatment of sarcoma of the long bones? By no means. This study of end-results, however, in my opinion, forces us to the following conclusions:

1. The routine treatment of early operable cases of osteogenic sarcoma by irradiation, which has become more and more general in recent years, should be abandoned.

2. Preliminary or pre-operative irradiation, *e.g.*, for a few weeks or a month, while waiting for a number of radiologists to pass on the roentgenograms, is without justification and is associated with grave risks.

3. While our present data are insufficient to permit a positive opinion as to the value of post-operative irradiation after amputa-

tion, my own feeling, supported by that of Forssell and others, is that osteogenic sarcoma is so radioresistant that it is doubtful if irradiation would control pulmonary metastasis that might have been present but undetected at the time of the amputation.

4. There is a type of osteogenic sarcoma known as "periosteal fibrosarcoma," characterized by little involvement of the bone itself, and of a much lower degree of malignancy than is the ordinary osteogenic sarcoma, that we have found most responsive to treatment. Three patients with this type have remained well for three years and one for nearly two years; one was treated by irradiation alone, and three by irradiation combined with Coley's toxins. While the period of time is too short to allow us to regard these cases as cures, I believe we are justified in using conservative treatment in this type of bone sarcoma, notwithstanding statements that no case has been found permanently cured with anything short of amputation.

5. For all other types of operable osteogenic sarcoma of the long bones, I believe that an amputation as soon as the diagnosis has been made, followed by prolonged treatment with Coley's toxins, is the method of choice. This method has given a much higher percentage of five-year cures than has amputation alone or amputation following prolonged irradiation.

6. The endothelial myeloma type of bone sarcoma is highly sensitive to both irradiation and Coley's toxins. While this type has often shown immediate and rapid improvement under irradiation alone—in some instances amounting to complete disappearance of the tumor in a few months—for some unknown reason this result has seldom proven to be lasting; recurrence or metastasis has developed within six months to a year, with a fatal ending in nearly every case. In cases of operable endothelial myeloma of the long bones we believe conservative treatment—local irradiation and Coley's toxins, should be tried for from four to six weeks before advising amputation.

7. Irradiation is of considerable value in many cases of inoperable osteogenic sarcoma because of the retarding effect upon the growth of the tumor and the relief of pain. On the other hand, the pain is not always relieved by irradiation, and the retarding effect may be of short duration.

8. It is well to recognize that there are certain cases of far-advanced inoperable osteogenic sarcoma which had best be treated without irradiation or toxins. Small doses will be of little avail, and irradiation pushed to its limits has not infrequently caused severe burns that heal but slowly or never heal, thus greatly aggravating the sufferings of the patient. Morphine is the method of choice for such cases.

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THE PHYSIOLOGIC INTERPRETATION OF DUODENAL MOTILITY[1]

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THIS subject is far from settled and unanimity of opinion is still being sought in the interpretation of duodenal motility. Various clinicians are attributing symptom-complexes to supposedly pathologic contractions of the duodenum (19), and are suggesting operative procedures as a cure. Certainly a disturbance demanding such radical treatment cannot be studied too carefully or too frequently. The following impressions are the result of five years of observation.

At first, all gastric cases were observed and studied and notes were made on the motility, form, and size of the duodenal curve. This group comprises well over two thousand cases studied at the Cook County Hospital. Later, as comparative studies became necessary, five other groups were added. These were as follows:

1. Visceroptosis with no abdominal complaints, 50 cases.
2. Hypertonicity with no abdominal complaints, 50 cases.
3. Proven gall-bladder pathology, 50 cases.
4. Gastric ulcer, 25 cases.
5. Active duodenal ulcer, 100 cases.

Before one can appreciate the possible disturbances in motility in the duodenum, a short review of the anatomic relations is necessary (8). The first portion, or duodenal cap, usually leads upward and obliquely backward into the descending portion. The second portion comes in relation with the gall bladder, so that infections in this organ have been frequently blamed for stasis and surging in the duodenal curve. The third, or horizontal, portion crosses the spine and the aorta, and lies underneath the mesentery and superior mesenteric artery. Various authors have attributed apparent obstructive signs to a narrowing of the opening at the duodenojejunal flexure, at which the ligament of Treitz is found. Many peritoneal folds have been described, but they are rather rare and of little importance. Plain muscular fibers have been delineated in the ligament of Treitz. The possibility of sphincteric action at this point will be considered later. The nerve supply of the duodenum arises in the solar plexus, but there is also an intrinsic nerve supply from the Meissner plexus. This double nerve control may account for some of the variations seen in normal cases.

In the study of our cases, careful notes were taken of the size of the duodenal cap, the angle formed by the cap and the descending portion, which we have called the cap angle, the size of the descending portion, the course over the spine, the length and steepness of the ascending portion, which we have called the duodenal climb, and the angle at the duodenojejunal junction, which we have called the Treitz angle. Observers at different times have pointed to all of these anatomic divisions as the locations of frequent obstructions. Keeping this in mind, we studied the flow of the barium through these areas with and without manual aid, and in the upright, horizontal, and reversed Fowler positions.

VISCEROPTOSIS WITH NO ABDOMINAL COMPLAINTS

In the normal hypotonic individual, the duodenal curve is usually "V"-shaped. The cap angle between the first and second portions is frequently sharp, but in none of our

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Fig. 1. Arrows point to an apparent obstruction in the horizontal portion, which is, however, only physiologic delay. Dilatation of the duodenal curve is due to rapid emptying of the stomach in carcinoma of the antrum.

Fig. 2. Apparent obstruction of the second portion which disappears after several minutes.

50 cases of visceroptosis was there any delay or obstruction at this point. In over 90 per cent of these cases, the second portion of the curve ended in a puddle which was moderately dilated. In 80 per cent slight but easily demonstrable delay was noted in the region of the superior mesenteric artery. Over 90 per cent showed an almost perpendicular duodenal climb to the Treitz ligament. About the same percentage of cases showed an apparent delay at the ligament of Treitz. Physiologic stasis was noted in every case. Stasis is difficult to evaluate; observers seem to disagree as to what stasis actually constitutes. Wheelon (2) considered stasis present when the barium had not moved on after the second gastric peristalsis. We believe that this definition, presuming a dependence of duodenal motility on gastric peristalsis, is a step in the right direction. It is our opinion, however, that the motility of the duodenal curve depends not only on the stomach, but also on the stimulation of the duodenal mucosa by the barium. The understanding of this double origin for peristalsis is essential to the correct interpretation of the motility of the duodenal curve.

When the hypotonic stomach first receives barium, it is most frequently quiescent. In the upright position, if peristalsis is present at all, it is feeble. Now if barium is forced by hand through the pylorus into the duodenal curve, one of two things results: either the barium lies quietly in the curve (normal stasis), or else surging movements are present. In either type there is little or no forward movement of the barium. Stasis will be present as long as peristalsis in the stomach is absent or inefficient. It seems that the nervous stimulus associated with gastric peristalsis is carried over into the duodenum. We have seen stasis persist for over five minutes at a time in the duodenum with only an occasional writhing movement. The barium is seen incompletely outlining the second portion, but most of

it remains in a puddle at the lowest portion of the curve. We have called this physiologic stasis, as differentiated from pathologic forms, to be described later. The puddle is usually moderately dilated, but it is considered normal and not due to obstruction.

Surging movements in the duodenum were seen in practically every one of the normal hypotonic stomachs examined. Surging is evidenced first in the puddle by mild writhing movements. When more barium is forced by manipulation into the curve, the writhing increases until it reaches a state of surging. Now one can see a marked contraction ring start in the center of the puddle of barium, and travel both toward the bulb and the duodenojejunal flexure. This two-way action is characteristic. It may force the barium into the bulb or the stomach, and into the jejunum. We are impressed with the idea that this surging is an intrinsic effort on the part of the duodenal curve to pass the barium along without the aid of the stimulation from the progressive gastric peristalsis. If the curve is compressed by the finger just proximal to the two-way peristaltic movement, the peristalsis then becomes more effective and barium is shot through the duodenojejunal flexure. The finger supplies here what the ordinary *vis a tergo*, which plays an important part in duodenal motility, from the progressive gastric peristalsis normally supplies. These localized, non-progressive, peristaltic movements in the duodenum have their counterparts in the stomach, when barium is first ingested by the patient in the upright position. At first the peristalsis is slight, occurs on one or the other curvature, is irregular in appearance, is very shallow, and does not reach the pylorus. As the stomach passes this irritable phase, the more normal progressive and complete peristalsis takes place. And so it is with the duodenal curve. Even when the progressive gastric peristalsis sets in quickly, the duodenal curve may still

Fig. 3. Marked organic constriction of the duodenal curve, due to carcinoma of the pancreas. Note the absence of dilatation of the cap. There was no surging during fluoroscopy. Even a very small lumen is sufficient to carry on the work of the duodenal curve.

show surging in the intervals between the gastric peristalsis. But in the light of the two origins of the nerve stimuli for duodenal motility, this can be readily understood. The surging here is due to the stimulation of the mucosa of the curve by the barium. After the gastric peristalsis has been well regulated for some time, the surging in the duodenum is considerably decreased. Very frequently we have waited for an interval of 30 minutes and then studied the duodenum again without giving more barium. It is surprising how little surging one will then see, even with the patient in the upright position. The time element is important in judging the motility of the stomach and duodenum. If one will allow the patient to rest and then re-examine the stomach, the diagnosis of duodenal ob-

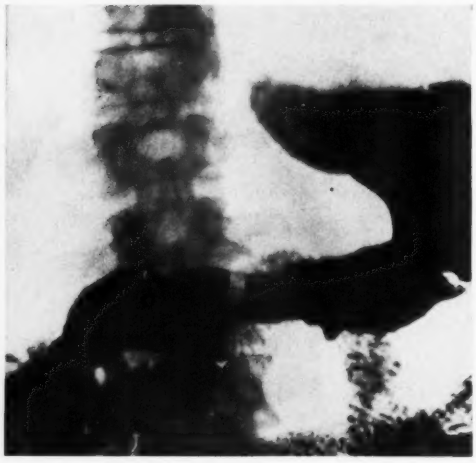

Fig. 4. Apparent obstruction of the duodenal curve which disappears after several minutes. This is probably due to the root of the mesentery or to sphincteric action.

struction and pathologic surging will be infrequent.

A rather striking example of the necessity of gastric peristalsis, before normal motility arises in the duodenum, is seen in cases of hypotonia. As stated before, at the outset of the examination, one will see most frequently the physiologic stasis and surging associated with the atonic stomach. Now if the patient is placed in the right oblique horizontal position, the progressive movement of the barium is considerably improved. Because of this, many authors have concluded that this position overcomes the obstruction caused by the spine, mesentery, artery, etc. We cannot confirm their conclusion without many reservations. In practically all of such cases we have noted improvement in the duodenal motility, but always it followed the appearance of vigorous gastric peristalsis. It is apparent that the right oblique horizontal position is best for the onset of gastric peristalsis, and we consider this responsible for the improvement in duodenal motility. Now if the patient is placed in the supine position and barium is forced into the duodenal curve by hand, stasis again sets in, simply because, in the supine position, the progressive peristalsis of the stomach is diminished.

This interrelation between gastric and duodenal peristalsis is also seen in those few cases in which active peristalsis is noted in the stomach at the beginning of the examination. In such cases, frequently the first portion of the barium swallowed shoots right through the duodenal curve and out past the ligament of Treitz. Later, as the stomach fills and becomes atonic, in the asthenic types, stasis and surging set in. This unusually rapid propulsion of the first bolus speaks against the theory of Carlson (18), who states that surging and stasis are physiologic for the purpose of mixing the duodenal contents with overflow gastric juices.

Several other observers, in attempting to explain surging pathologically, have reported a very close association between surging and belching. One author, Wheelon (2), believes this relation so close that, in his examinations, he was able to foretell accurately just when the patient would desire to belch. For this reason, many of the symptoms of dyspepsia have been attributed to duodenal surging. Our own observations have been entirely different. Repeatedly we tried to elicit complaints from patients during the period of surging, but we could never persuade ourselves that there was any interrelation between the findings. In this connection, it is interesting to note the effects of mild, shallow, reversed peristalsis in the stomach. We have observed many such stomachs and here, again, we have not been able to show any constant relation between reversed peristalsis in the stomach and belching. We are convinced that the cause of this symptom does not lie in what we are calling physiologic surging.

Still another method for studying the relation between stomach and duodenal motility is the artificial inducement of gastric

peristalsis in the upright position. By vigorously massaging the abdomen, peristalsis will ultimately set in and a distinct improvement will be seen in the duodenal motility.

THE HYPERTONIC STOMACH

The hypertonic stomach was studied in a group of 50 selected cases. In these, the duodenal curve is usually shorter, rounder, and does not rise as high as in the hypotonic type. The cases were studied along the same lines used in the hypotonic cases. The angles were carefully examined for obstruction, and the height of the duodenal climb measured.

That physiologic stasis was not as frequently seen as in the hypotonic cases is explained by the fact that, in the hypertonic types, active peristalsis in the stomach comes on immediately, stimulating progressive peristalsis in the duodenal curve. This is found to be true except in those cases in which pylorospasm is present. Here the duodenum shows only writhing. Occasionally the stomach is seen in a tonic contraction, showing deep, non-progressing, peristaltic waves. During this stage, stasis in the duodenal curve is noted, again indicating the close relation between progressive gastric peristalsis and duodenal motility.

Physiologic surging was frequently seen, but for short periods only. Occasionally the surging was marked and barium was swept back in the bulb, which can be explained by physiology. In hypertonic types, the intrinsic peristaltic mechanism is naturally more irritable. In these cases, when barium is forced into the duodenum by hand, there is an immediate attempt to move it along the canal. Frequently it is forced in an opposite direction. The relation between symptoms of dyspepsia and surging was again studied in this series and the same results obtained. No definite association was found to be present. There were other small differences between the hypertonic and

Fig. 5. Normal stomach. Note the large cap and small duodenal curve. Normal variations.

hypotonic stomachs; for example, the puddle formation was very rarely seen. The curve itself was rounder. Angulations were very rare. The duodenojejunal flexure was almost never in question. In short, the hypertonic type of duodenal curve rarely caused any difficulty in differentiating between the normal and the pathologic.

SUPERIOR MESENTERIC ARTERY

Numerous observers (7) have reported cases of obstruction with symptoms due to compression of the third portion of the duodenal curve by the superior mesenteric artery, the root of the mesentery, or the ligament of Treitz (16). They have gone so far as to devise operations in which the duodenal contents are shunted into the jejunum, so that the question has a serious aspect. In the several thousand cases we examined, we were not able to convince ourselves of a single definite case of pathologic obstruction at the root of the mesentery or the mesenteric artery. And, in spite of

many observations by surgeons during operations, we have never been able to demonstrate a pathologic kinking at the ligament of Treitz in an adult. Such discrepancies in observations are striking, and it may just be that here, again, it is a question of definition. What shall constitute a state of obstruction? We do not believe that narrowing to the touch of the finger at operation is sufficient. We have already shown that stasis and surging are dependent upon the type of stimulation of the duodenum, and not upon the presence of obstruction. What then shall we mean by obstruction?

In our work, we laid down the following prerequisites before making a diagnosis of pathologic obstruction.

1. *Strong, but Ineffective Peristalsis.*—The peristalsis must be vigorous beyond the normal. In this connection, significant observations can be made on the stomach which is laboring against a pyloric obstruction. One will note here vigorous hyperperistalsis, which is not able to force the barium through into the duodenal bulb. As the wave approaches the pylorus, the barium slips back into the pars media, through the center of the lumen of the stomach. This two-way flow of the barium is readily seen in cases of pylorospasm. Yet why do we not see reverse peristalsis in the stomach? The obstruction must be high-grade, indeed, before the reverse peristalsis is seen; even then peristalsis is only slight. Can we compare reverse peristalsis with the vigorous to-and-fro movement of the duodenal curve? We believe that the etiology is not the same. The reverse peristalsis of obstruction is slight, shallow, and never as active as that seen in the surging of the duodenal curve.

2. *Dilatation.*—Wherever obstruction occurs in the course of a hollow viscus, dilatation is always seen proximal to the obstruction. Dilatation, in every case, is in direct proportion to the severity and duration of the obstruction. We could certainly expect considerable dilatation of the duodenal curve in an adult who has long had supposed obstruction. Yet, in all of these cases of surging, never once could we definitely determine more than a very slight dilatation of an obstructive nature. In cases of puddle formation, there is mild dilatation, but this is only a question of gravity, and the dilatation never goes beyond the borders of the puddle. It seems to us that, in any case of duodenal curve dilatation due to obstruction, the cap should also be dilated. This we have hardly ever seen without finding other congenital anomalies.

3. Thickening of the wall of the viscus is practically always seen if obstruction is present. This is important. If a surgeon reports narrowing of the duodenojejunal flexure, he must show that the duodenal curve is thickened, otherwise he cannot presume that the narrowing is the cause of symptoms.

The diagnosis of obstruction, however, is not without some foundation in many cases. While we do not consider them true pathologic obstructions, we have seen many cases presenting what we consider physiologic delay, at the superior mesenteric artery and the Treitz ligament. It is seen in about 70 per cent of all hypotonic cases. Barium fills the descending and transverse portions up to the region of the spine, then it is sharply cut off from the rest of the empty curve. This is seen best in the upright position. When the peristaltic wave becomes progressive in type, the barium flickers through the physiologic compression. At the most there is only a slight clumping of the barium proximal to the artery when the duodenum is at rest. When peristalsis sets in, the compression is easily overcome, even with the patient in the upright position. We have carefully examined our asthenic patients in all postures, and we feel that this physiologic compression is only slight and that there is only slight decrease of this compression in the horizontal position. The improvement of peristalsis in the duodenum in the hori-

zontal position is due to the onset of active gastric peristalsis, as has been shown previously. Writhing frequently appears to stop at the crossing of the artery, but this is only apparent. Because there is no barium in the distal half of the duodenum, writhing cannot be seen.

The same observations were made in the study of the delay noted at the duodenojejunal junction. Weak, ineffective waves frequently were unable to force the barium up the climb and through the junction, when the patient was in the upright position. Yet there was no dilatation proximally, there was no retention, and vigorous peristalsis found no difficulty in overcoming the angle. Occasionally the ascending portion of the duodenum was so steep and long that gravity alone kept the barium from spilling over into the jejunum. In such cases only vigorous peristalsis was effective. With weak peristalsis, the barium fell back into the puddle. It is in the case with the long steep climb that improvement is noted in the prone position, for then the action of gravity is removed and barium passes more readily into the jejunum.

In the hypertonic cases rarely was excessive pressure by the mesenteric artery seen. In addition there was seldom a long ascending portion of the curve, so that progressive movement of the barium was more commonly noted.

We have now studied the motility of the duodenal curve in known normal asthenic and sthenic cases. We have seen that, in certain types, there is a certain amount of physiologic stasis and surging. Using this normal degree as a base line, can we recognize an abnormal increase of this phenomenon and, if so, is this finding significant for any particular symptom-complex? For our study, 100 cases presenting active duodenal ulcers were chosen. After calculating the results, we were unable to find any increase over the normal in stasis and surging.

A series of 25 cases of gastric ulcer was similarly examined and here, also, no appreciable change in the duodenal motility was noted. Of course if pylorospasm existed, there was an increase in stasis; but this merely showed the importance of the *vis a tergo* principle in the duodenal motility and the necessity for a sufficient amount of barium before progressive peristalsis would occur.

To complete the study of the upper right quadrant, a carefully selected group of 50 cases of gall-bladder pathology was chosen. Here again the same results were found. There was no appreciable increase in stasis and surging. We realize that this is in direct contradiction to the work reported by Friedman, Strauss, and Arens (21) and it is not easy to account for such marked difference of opinion. We started this study with the conviction that increased surging would be found in ulcer and gall-bladder pathology, but we were forced to change our opinions. Some of the differences in reports may be attributed to the time of observation of the duodenum. We frequently found surging at first, and, later, more progressive peristalsis, when the stomach became more active. Again, surging was often seen in the upright and not in the horizontal position. Results calculated on first observations might, therefore, be untrustworthy. We do not offer this as a criticism of the authors mentioned, but merely point out the necessity for prolonged observations in carrying out a study of these cases.

Theoretically, several interesting deductions can be made. Those who point to surging as an indication of duodenitis, due to gall-bladder or ulcer pathology, do not take into consideration the action of the gastrointestinal musculature in known cases of inflammation. For example, let us take a case of tuberculosis of the cecum. No one has described surging in such a case. On the contrary, the increased irritability of the cecum keeps it practically free from barium.

Fig. 6. Normal physiologic delay at the right border of the spine. Active peristalsis has no difficulty in overcoming this apparent obstruction.

Inflammatory conditions of the intestines are usually associated with diarrhea. It is Nature's way of removing the foreign irritation. Why should inflammation in the duodenum behave differently from inflammation in any other hollow viscus? If there really were a duodenitis involving the descending portion, the last finding we would expect would be stasis and surging. In fact, the evidence appears to indicate that duodenitis is a rare occurrence and that when it is present it is of little importance in the x-ray examination.

Again, theoretically, we cannot confirm the diagnosis of intermittent duodenal obstruction (16). Those who report such cases claim that the obstruction is caused, during certain postures, by the superior mesenteric artery (13) or a narrow Treitz ligament (14). This explanation does not run parallel with the clinical findings in our cases. Very frequently the symptoms of dyspepsia will disappear for weeks at a time. Certainly, the anatomy of the duodenal curve did not change during our weeks of study. To afford some proof of this opinion, we selected 15 cases of visceroptosis presenting symptoms of dyspepsia. We examined them during their periods of complaint, noting the stasis and surging, and reexamined them during their periods of well-being. The stasis and surging were again noted, and to the same degree. In the face of these findings, we were forced to conclude that the duodenal curve motility was not the cause of the dyspepsia. To speculate, it is more likely that the anatomy remains constant and has nothing to do with the symptoms. Again, many of these cases complain of the same symptoms on an empty stomach and on a full stomach. If duodenal obstruction were really the cause of the complaint, the patient should be symptom-free on an empty stomach.

We have had 10 cases of large diverticula of the second portion of the duodenum. Stasis existed in these for at least 24 hours. Certainly one might expect symptoms, if stasis in the duodenum causes symptoms, yet in each case other definite pathology, such as gall-bladder disease and ulcers, was found to account for the complaints of the patient.

Perhaps the most frequent cause given for supposed duodenal obstructions is compression by the mesenteric artery. This would seem to be supported by the postmortem experiments carried out by McWhorter (7), who, when the mesentery was pulled downward, was able to demonstrate definite compression of the duodenum by the artery. It is significant that he was unable to cause similar compression by dragging on the ligament of Treitz. Our own clinical and fluoroscopic observations agree somewhat, but our interpretations are different. It is true that careful fluoroscopy will show a delay in the duodenal curve in the region of the spine in the upright position, but the degree of delay does not seem to vary with the drag on the mesentery. A patient with a very low hanging stomach does not seem to present more stasis and surging than one with moderate ptosis. Again, in the reverse Fowler position, when the mesenteric drag is removed, stasis and surging do not disappear entirely. In any

event there is no associated dilatation of the proximal portion of the curve, and, as soon as vigorous gastric peristalsis sets in, the duodenal loop begins to empty nicely.

Acute angulation at the Treitz angle has also been mentioned as a cause of obstruction in asthenic types (25). It is true that, in the upright position, barium will be seen, particularly in asthenic cases with a steep duodenal climb, forcing its way up to the angle and then dropping back to the puddle. And yet, even in these cases, one frequently sees the barium leave the puddle and shoot right through the Treitz angle, which apparently is not narrowed. One can only conclude that there is no real obstruction to the right kind of progressive vigorous peristalsis. And yet a steep duodenal climb does cause delay in the upright position, for, in the horizontal, the tendency to fall back into the puddle is definitely decreased. We do not contend that there is no apparent evidence of obstruction, but we do say that it is only physiologic and frequently dependent upon the position of the patient.

One case in particular comes to our minds. The patient was a young laboratory technician who had irregular attacks of abdominal distress, interspersed with periods of well-being, sometimes lasting many weeks. Examination revealed a markedly enlarged duodenal cap and curve. There was an apparent kinking at the ligament of Treitz, or, at any rate, the steep duodenal climb resulted in many ineffectual peristaltic movements in the distal portion of the loop. Superficial observation here would immediately have laid all the symptoms to a narrow duodenojejunal flexure. But how could we account for the weeks of well-being? It did not seem possible that an organic obstruction at the Treitz ligament would be present one day and not the next; furthermore, examination of the colon showed a very large redundant sigmoid. We felt that the megaduodenum was a congenital anomaly, just as the sigmoid enlargement was.

Many other causes of obstruction in the duodenum have been listed, including gastroptosis, cecum mobile, peritoneal bands, tumors of the abdomen, and prominent spines. In our cases, we were able to demonstrate only one real pathologic obstruction —a case of carcinoma of the third portion of the duodenum. Bakay (5) reports only 12 cases of pathologic obstruction seen at operation in 10 years of observation. There is an unaccountable difference of opinion which only time will clear up.

One might have expected that surgical experience would have easily solved this problem, by the operation shunting the duodenal contents from the second portion of the duodenum directly into the jejunum. In this connection apparently successful operations have been reported by Griffith (23), Kellogg and McKenty, who are quite enthusiastic. For them the problem seems to be solved. Unfortunately, equally as able surgeons have reported dismal failures. Robertson and Devine (1) and Miller and Gage (10) are convinced that operation has no lasting effect upon the symptoms, which they ascribe to a neuromuscular disturbance. These men attribute the temporary effects to the rest in bed, the proper diet, and the psychologic effect of an operation on a neurotic patient.

We have frequently noted pathologic findings in the duodenum after gastro-enterostomy. In several cases we were able to demonstrate a definite narrowing between the distal and proximal loops adjacent to the new ostium. If surging were an indication of obstruction, certainly here one ought to find it to a marked degree, yet, much to our surprise, it was practically absent. The duodenal loop was considerably dilated and apparently contained a stagnant pool of barium. This was indicative of pathologic stasis and was always associated with nausea, vomiting, and other symptoms of dyspep-

sia. In these cases, instead of surging, we noted weak, inefficient peristaltic movements and occasional spasmodic hyperperistalsis, just as is seen in cases of obstruction at the pylorus. In cases in which gastro-enterostomy had been performed and there were no obstructions, again dilatation was noted. The barium gradually collected in the proximal loop, which emptied only partially. There was always a moderate degree of pathologic stasis, attributed to lack of vigorous pyloric peristalsis, which, in turn, was due to the shunting of the barium away from the pylorus through the new ostium. Here again the dependence of efficient duodenal peristalsis upon similar gastric peristalsis was demonstrated. Frequently so little barium passes through the pylorus after gastro-enterostomy that the examiner does not realize the dilatation and pathologic stasis present in the duodenal loop. The nausea and vomiting complained of in these cases might easily be due to the bile collected in this loop. We have frequently noticed that barium will pass out of the new ostium quickly and then remain quiescent in the jejunum. There is no surging, there is no question of obstruction, there is only stasis. This again shows the interrelation between gastric and upper intestinal peristalsis.

We have frequently seen six-hour retention films shown demonstrating stasis in the duodenal curve. This has been interpreted by many as evidence of pathologic motility in the loop, but we cannot confirm that opinion. As long as barium remains in the stomach, barium will also be seen in the duodenum. In order to diagnose pathologic duodenal stasis roentgenographically, it is necessary to show an absolutely empty stomach, a dilated, filled duodenal curve, and an empty jejunum.

We have spent much time in showing that stasis and surging in the duodenum are physiologic except in certain cases of gastro-enterostomy. Can we offer any theory for the possible function of these phenomena? Some observers point to surging as the mixing function of the duodenum (6, 22). It is suggested that food too hurriedly extruded from the stomach is kept in the duodenal loop until it has become well mixed with the gastric secretion (24). This theory does not seem to cover all of the cases. How could one account for those in which there is no surging, and why should the asthenic type show the greatest degree?

McWhorter (7) adds a group of cases of duodenal ileus, which he has attributed to hyperthyroidism. The tendency to attribute surging to nervous disturbance, and not to mechanical obstruction, is becoming more and more pronounced of late. We can only wait for the future to tell us the truth. It is our belief that stasis and surging are just the results of the particular type of nervous and postural mechanism. This is the only theory that appears to account for most of the findings. Dr. Singer, in the gasto-intestinal clinic of the Cook County Hospital, in Chicago, has for many years made clinical and x-ray observations of cases showing stasis and surging. He also is of the opinion that an actual obstruction does not exist, but he does believe that the symptoms are due to the temporary lowering of the threshold of the sympathetic sensation centers. By this he means that certain patients at certain times actually feel the normal duodenal contractions and translate this feeling into pain.

We believe that, while such a theory answers many puzzling questions, there is no real proof at present. We are not even convinced that the symptoms these patients complain of are referable to the duodenum. It is possible that the future will reveal a definite function of this surging, but at present all we can say is that it is physiologic and it must not be considered as the cause of symptoms.

CONCLUSIONS

1. Duodenal motility was studied in over two thousand cases.

2. Normal hypotonic and hypertonic cases were used as controls.

3. Duodenal ulcer, gastric ulcer, and pathologic gall bladder did not affect normal stasis and surging.

4. Mechanical obstruction does not account for either the x-ray signs or the clinical symptoms.

5. Surgical reports are frequently diametrically opposed.

6. The function of surging has not been established. It is believed to be physiologic.

7. At present there is insufficient proof for the theory that the symptom-complex is due to the lowering of the threshold of the sympathetic sensation center.

8. Stasis and surging are due primarily to the neuromuscular mechanism, and, secondarily, to the mechanical conditions found in different types of patients.

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GIANT-CELL BONE TUMOR

SOME CONSIDERATIONS OF TREATMENT[1]

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THE neoplasm with which we are to deal needs no elaborate discussion of morphology or classification here. We have shown in a previous communication (1931) the conformity of the original description by Robin and Nélaton with that by Ewing, whom we consider as the authority to-day.

Giant-cell bone tumor is that process which is characterized by a sharply demarcated central tumor of bone in which large multi-nucleated giant cells predominate, either through the whole mass or in scattered masses. The nuclei are centrally placed as distinguished from the foreign-body giant-cell with peripheral nuclei. These cells may enclose blood and cell detritus, bony granules, or lipoid. There are many fine capillaries, and a spindle-celled stroma, sometimes cystic spaces with bloody fluid. Bone formation is not common save at the periphery, and islands of cartilage are found in some. These may be isolated cartilaginous remnants, or fragments of the epiphyseal disc undergoing destruction by the tumor. It is a neoplasm essentially benign, but which, on repeated irritation by surgical or other trauma, may show progressive development of increased cellular proliferation, with perhaps ultimate transition of a part into a true malignant neoplasm capable of dissemination and growth. Further, giant-cell bone tumor in our experience is limited by the epiphyseal disc during the growth period, being found only on the diaphyseal side of that growth area in the long bones; *i.e.*, in the metaphysis. After closure of the epiphysis the neoplasm may invade to the cartilaginous coating of the articulating bone end.

Nélaton demonstrated the probability of regrowth from very small fragments left in the process of a surgical attempt to curette the mass from its bone host.

This is not the place for a discussion of the merits of the belief, held by some observers, that there are certain primary variants of the giant-cell bone tumor which are potentially malignant. We do feel that there is logical probability that, in response to repeated demands for excess reparative activity on the part of the mesoblastic cells of this tumor, growth restraint may be progressively diminished and actual malignant degeneration ensue. In this we again follow the teaching of Ewing, and have reported two cases of malignant degeneration from our own series. It is fully as conceivable that less differentiated bone components should throw off restraint and grow wildly, as that carcinoma cells should arise from what have previously appeared to be well-disciplined epithelial cells.

There is a peculiar coincidence—at least, from the patient's viewpoint—of previous trauma to the part, perhaps minimal in character, or oft-repeated. Thus, one can understand readily the belief of Gross and others that the production of the giant-cell tumor is a reversion of the bone marrow to an embryonal state, or is a sequel to the normal response incident upon trauma and repair. And, by a similar process, there may be adequate evidence that the bone proliferation which is common along the septa or trabeculæ separating the conglomerate small masses from each other is a repair mechanism. This bone formation unquestionably increases after the increased maturation of the cells following roentgentherapy.

Bloodgood, in an opening paragraph of a discussion of "benign bone cysts, osteitis

[1]Read before the Radiological Society of North America at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

fibrosa, giant-cell sarcoma, and aneurysm of the long-pipe bones" (1910), made the following statement:

"Treatment of tumors which will insure the patient the greatest possibility of a permanent cure with the least mutilation will be accomplished only when surgeons have a better conception of the local growth of neoplasms, both benign and malignant, and are able to diagnose with differentiation the various lesions at the exploratory incision with, *or better without,*[2] the aid of a rapidly frozen section.

"This is especially true of bone lesions. . . ."

To-day, this carries considerable interest in reference to the problem at hand: first, because since that time the nicety of roentgen diagnosis has so developed that, in experienced hands, few bone tumors remain which cannot be allocated to their proper major class by that means. Hence, in large measure the necessity, and definitely the advisability, of exploratory incision is reduced. Second, we are particularly concerned here with the "treatment of tumors which will insure the patient the greatest possibility of a permanent cure with the least mutilation."

A consideration of the treatment of giant-cell bone tumor must then take into cognizance that one is to deal with an essentially benign but progressive metaplasia of bone elements. This tumefaction may offer definite danger of disability, if not arrested or eradicated, because of the prevalence of involvement of the weight-bearing ends of the long bones. Concurrently, radical surgical treatment seeking to eradicate the neoplastic area engenders that mutilation of which Bloodgood spoke.

We have indicated above that one should, with rare exception, make the diagnosis of this expansile, often trabeculated, sharply limited tumor of bone by adequate roentgen study. Thus the necessity of surgical approach for diagnosis is obviated. One must consider essentially the method of treatment which will offer the patient the greatest promise of cessation of growth of the neoplasm and, equally important, the continuance of maximum function.

For the observers before and since Nélaton until the present development of roentgentherapy, the surgical approach was the method of choice. Many, however, have not been fully conscious of the advisability of the thorough curettage of the tumor mass followed by some chemical cauterant at the time of the first incision. The result has often been that there were repeated attempts at surgical removal, the patient suffering considerable disability meanwhile. Occasionally, of course, the surgeon finds it almost impossible to thoroughly curette and yet maintain adequate function, when the lesion is in a major weight-bearing area such as the head of the tibia or lower end of the femur. Further, amputation is a radical procedure which neither surgeon nor patient desires if avoidable.

Roentgentherapy in capable hands, however, has demonstrated its ability to impress upon the giant-cell tumor a certain restraint of growth, with subsequent changes in the area by the attempt of the normal constituents to change the irregular structures into a semblance of normal bone architecture.

This process of "growth restraint" may well be analogous to the changes in the life cycle of the blood cells after roentgentherapy, as demonstrated by Isaacs. If we may consider the bone tumor giant-cell as an osteoclast which has gone a bit wild in its cycle and grows in magnitude by cohesion of two or more, we may presumably think of it as a less differentiated or more embryonal unit. Such irradiation should cause it to become more mature, or reach maturity and senescence earlier, with resultant slow but progressive return of the area to a more normal architecture. This process may be indicated to a degree in that, in response to irradiation, the giant-cell bone tumor seems to increase in bone lysis from three weeks to two months after the initiation of such

[2]The italics are the writer's.

treatment. At the end of that time usually, one sees the beginning of a rapidly progressive new bone formation in the formerly osteolytic area. If we have access to the tissue at about one month after roentgentherapy, we find evidence of a marked senescent change in the giant cells. They are shrunken, dehydrated, the nuclei closely packed in the center, the protoplasm granular—many have died and disintegrated, leaving only spaces in the stroma with much scattered chromatin dust. Subsequently the normal bone cell-components build a new bone, almost normal in architecture, upon this empty framework and débris. Further, in support of roentgentherapy, there is the absence of external trauma, which from the cosmetic standpoint is often important.

Also, the older literature is rather full of warning in regard to the prevalence of infection and of hemorrhage in the giant-cell tumor after surgical attack. The infection should not be a barrier to-day, with the perfection of aseptic technic, save in those instances of a focus for growth of a blood-borne infective agent in a traumatized area.

Another point in favor of the irradiation method is the elimination of the factor of hospitalization for surgery and more positive disability for a period.

The recent paper by Simmons in analysis of the cases from the Bone Sarcoma Registry emphasizes the diversity of opinion in the matter of treatment. The unfortunate lack of follow-up material in the form of subsequent roentgenograms makes conclusions from this series inadvisable. It is interesting that in this series irradiation produced a reported clinical cure in from 73 to 75 per cent of the cases in the group, curettage together with other agents only from 63 to 72 per cent.

The 19 cases of giant-cell bone tumor in the records of the University Hospital from 1923 to 1931 have been analyzed fully in our previous paper: 14 have been confirmed by histopathologic study. Of the 19, 10 are considered clinically well. The mode and sequence of treatment are indicated in Table I. Five are considered unfavorable, showing evidence of recurrence either before or after admission to the clinic, two were malignant, and two were untreated in any way. One of these latter patients has since reported in a cursory fashion to a leading hospital and received some roentgentherapy, but has not co-operated with the physicians in charge. Those clinically well, it should be noted, received roentgentherapy, one with curettage, four with curettage and chemical cautery (phenol or acriflavin), and one excision only. Of the recurrences, all showed an irregular program of treatment, either interruption of roentgentherapy by surgery, or roentgentherapy as a last resort after surgery had proved unsatisfactory.

TABLE I.—GIANT-CELL BONE TUMOR CASES, 1923-1931

Total number of giant-cell bone tumor cases by roentgen diagnosis in period	19
Number confirmed by microscopic section	14
I. Recurrences	5
Roentgentherapy: premature curettage: returned for further roentgentherapy five to six months later	2
Roentgentherapy: premature curettage: returned for further therapy 7 months later: excision without waiting for irradiation effect	1
Curettage: recurrence, 6 months: referred for roentgen treatment 6 months later: symptomatic improvement	1
Partial curettage: roentgentherapy started: patient did not return: recurrence or further growth	1
II. Malignant neoplasm associated with giant-cell tumor	2
III. Clinically cured	10
Roentgentherapy only	4
Curettage: roentgentherapy	1
Curettage: cauterization (chemical): roentgentherapy	4
Excision	1
IV. Untreated	2

We feel definitely with Herendeen and Pfahler that roentgentherapy offers the best opportunity for control of this type of bone tumor with the least damage to the patient. The voltage to be used depends on the depth and thickness of the tumor. In this series from 120 to 200 P.K.V. has been used with relatively equal success, the filtration being

varied to conform to the best judgment for the quality of the radiation produced by a certain voltage. Divided doses at increasingly longer intervals have been the rule.

SUMMARY

1. Giant-cell bone tumor demonstrates a definitely favorable response of the order of "growth restraint," or, earlier maturation and senescence of the tumor cell, under roentgentherapy.

2. Surgical treatment at best does not seem equally satisfactory from the standpoint of control of further growth, minimal trauma to the patient, and minimal disability. When used, it should be accompanied by chemical cauterization of the cavity and adequate roentgentherapy.

3. Roentgentherapy alone is advocated as the method of choice in this type of bone tumor. If surgical attack is advisable from the functional or cosmetic standpoints, it should include chemical cauterization and associated pre-operative and post-operative roentgentherapy.

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CHRONIC LYMPHATIC LEUKEMIA INVOLVING THE GASTRO-INTESTINAL TRACT

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THE literature concerning leukemia and allied diseases of the lymphatic system establishes the impression that any attempt to assign a clinical case to a specific category of the disease is somewhat hazardous. Especially is this true concerning diverse manifestations in various organs. Descriptions of leukemic and aleukemic deposits in the gastro-intestinal tract impress one with their marked similarity, and suggest that their differences might well be construed as variations of one fundamental disease.

Accounts of these conditions by various authors have resulted in a chaotic literature, due principally to a lack of standardization of terminology and classification, the inconstancy of which is especially evident regarding leukemic deposits throughout the gastro-intestinal tract. The extreme variability in terminology associated with the classification of lymphatic tumors has resulted in the suggested use of the word "lymphoblastoma" (31), the term to include the principal neoplastic manifestations of lymphatic leukemia, aleukemia (pseudoleukemia), lymphogranulomatosis (Hodgkin's disease), and lymphosarcoma. The necessity for such an inclusive term illustrates the extreme difficulty of attempting to confine a study to any particular manifestation of lymphoid disease.

Thus, a review of the literature in an attempt to determine the frequency of occurrence of a single type of case becomes extremely difficult. Some idea of the frequency of the condition may be gained from data relative to its occurrence in general autopsy material. Seventy-seven cases of leukemia were found in a recent survey (16) of 12,936 autopsies performed in the Department of Pathology of the University of Minnesota. Fifty-five of the cases were of the lymphatic type and 26 were of the myelogenous type. Two of the lymphatic leukemia cases showed local gastro-intestinal nodular and ulcerative lesions. One of the myelogenous group showed thickening of the walls of the gastro-intestinal tract, without nodule or ulcer formation. Consequently it is probably safe to state that the lymphatic leukemia type of gastro-intestinal lymphoblastoma is quite uncommon. It is for this reason that the following case report is presented.

CASE REPORT

The case is that of a white male, 62 years of age, admitted to the University of Minnesota Hospital, June 4, 1929. Death occurred 73 days later.

History.—The patient had been apparently perfectly well until approximately two years before admission to the University Hospital, when he began to have difficulty in urination. He had trouble in commencing his urinary flow; the stream was small and only small amounts of urine were passed at any time. His condition was neither progressive nor disabling for a period of about one year. In November, 1928, however, he developed frequency and associated nocturia, but noticed neither blood nor cloudiness in his urine.

During November, 1928, the patient's abdomen suddenly became swollen and painful, the pain being dull and aching in character and present over the entire abdomen. His abdomen felt very hard, this sensation being increased by the ingestion of food or fluid. The patient's appetite had been constantly good and his defecations regular, except for a brief period of constipation a short time before admission to the University Hospital.

In February, 1929, he was hospitalized elsewhere, because of his urinary symptoms, and a urinary bladder stone was removed. This procedure failed to relieve his symptoms, and distention of the abdomen persisted. One month before admission to the University Hospital he developed edema of both ankles. The condition remained localized in the ankles, being the same in the morning as in the evening. During the period from November, 1928, to the time of admission to the University Hospital the patient had lost 20 pounds in weight. His chief complaints upon entrance to the University of Minnesota Hospital were those of urinary obstruction, painful enlargement of the abdomen, edema of the ankles, and marked loss of weight and strength.

Past history, marital and family histories were essentially negative.

Physical Examination.—The patient appeared markedly emaciated, but did not seem to be distressed. His pulse, temperature, and blood pressure were normal.

The abdomen was distended, rounded, and symmetrical in appearance. There was some bulging in both flanks, suggesting the presence of free intraperitoneal fluid. Percussion of the abdomen showed the liver to be about 2 cm. below the costal margins on both sides. There was percussion dullness in both flanks and over a mass in the region of the umbilicus. The mass extended from about 6 cm. above to about 2 cm. below the level of the umbilicus. It also extended to the right and downward from the umbilicus toward the right iliac fossa for a distance of approximately 8 centimeters. The mass was painless, firm, smooth, and slightly movable on palpation, changing in shape and size with peristalsis. An inconstant mass,

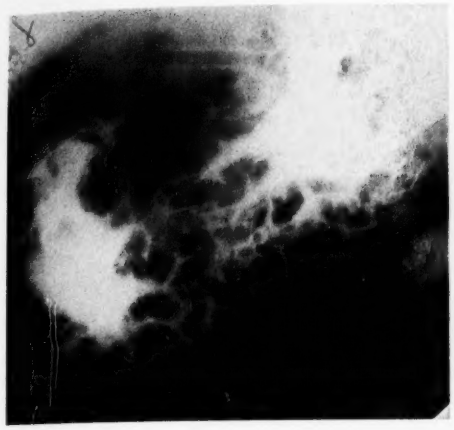

Fig. 1. An anteroposterior roentgenogram, using a barium meal, showing the appearance of the stomach and first portion of the duodenum. The mucosa shows a marked hypertrophy and irregularity from the cardia to the pylorus. The appearance suggests a severe gastritis or a diffuse polyposis. The duodenal bulb has a similar appearance.

Fig. 2. A roentgenogram, using a barium meal, of the colon. Considerable irregularity of the rectum and sigmoid colon are present, as well as a defect at the base of the cecum. The appearance suggests a pre-diverticular state of the descending colon and hypertrophied mucous membrane of the cecum and rectum.

thought to be an enlarged spleen, was palpated below the left costal margin.

The posterior cervical, axillary, and epitrochlear lymph nodes were enlarged. Rectal examination showed the prostate gland to be normal and there was no evidence of a rectal shelf. The residual urine, upon catheterization after voiding, was found to be 5 cubic centimeters. The remaining physical findings were normal.

Laboratory Data.—The urine was normal on repeated examinations except for the presence of numerous pus cells. Examination of the blood revealed: Hemoglobin 53 per cent; red blood cell count 2,610,000; white blood cell count 33,550; differential (polymorphonuclear neutrophils) 13 per cent, (polymorphonuclear eosinophils) 4 per cent, (lymphocytes) 82 per cent, (monocytes) 1 per cent. No immature cell forms were observed. Wassermann was negative. Icterus index 2.5, bromsulphalein liver function test grade 0 liver injury. Gastric analysis: free HCl before and after histamine 0.0; combined HCl before and after histamine 11.0.

Diagnostic Procedures.—X-ray studies of the chest were made on June 5, 1929. Neither tumor metastasis nor other pathology, except a chronic bronchitis, was demonstrated. On June 6, 1929, a gastro-intestinal study by the ingestion of a barium meal showed an enormously enlarged stomach extending to the right lateral wall of the abdomen and almost down to the pelvis (Fig. 1). The mucosa showed a marked hypertrophy and irregularity from the cardia to the pylorus. The appearance suggested a severe gastritis or a diffuse polyposis. In later views enlargement of the rugæ was demonstrated to be present chiefly on the anterior wall of the stomach. There was no gastric retention after six hours. The duodenal bulb could not be clearly visualized but the findings were similar to those of the stomach. The opinion at this time was that

the appearance suggested swelling of the mucosa, the individual folds standing out most prominently. This condition was thought to be consistent with an extreme chronic hypertrophic gastritis or polyposis of the stomach. Examination of the pelvic area of thickened rectal mucosa. Microscopic examination showed it to be normal rectal wall. An enlarged lymph node was removed from the left axilla, histologic study of this structure revealing only a benign lymphoid hyperplasia.

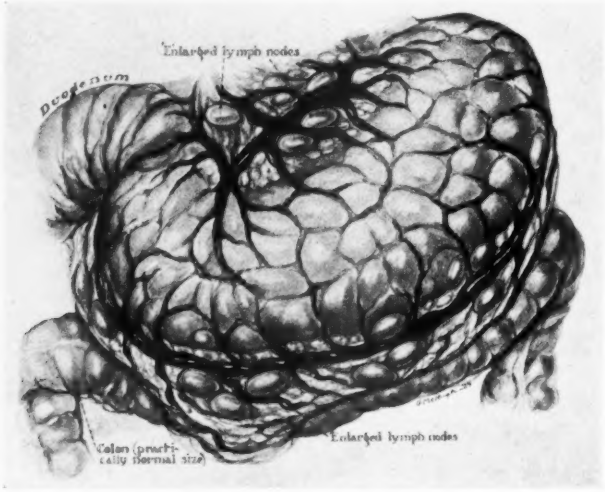

Fig. 3. A sketch, illustrating the appearance of the stomach at operation. The stomach presents an appearance of marked lobulation and there is a considerable enlargement of the paragastric lymph nodes. The first portion of the duodenum is seen to be greatly distended, while the colon is apparently normal in size.

bones showed some evidence of lumbosacral and sacro-iliac arthritis but none of tumor metastasis. On June 12, 1929, fluoroscopic and film examinations were made of the colon, using a barium meal (Fig. 2). There was considerable irregularity of the rectum and sigmoid colon, which suggested a combination of hypertrophied mucous membrane and a pre-diverticular condition of the descending colon. At the base of the cecum there was also evidence of a defect suggestive of a marked hypertrophy of the mucosa. No evidence of other pathology was observed. On the basis of this study a pre-diverticular state of the descending colon and hypertrophied mucous membrane of the cecum and rectum was suspected.

Because of the x-ray findings in the region of the rectum a biopsy was made of an

The patient was in the hospital 17 days before an exploratory laparotomy was performed. An attempt was made to improve his general physical condition during this time, for upon admission to the hospital he was much emaciated and consequently was considered a poor operative risk. The patient's appetite was good, and he had no complaints other than that of intermittent, dull, aching pain in the lower abdomen. The pulse rate maintained an average of about 90 beats per minute and the temperature was normal.

Diagnosis.—The historical data in the case were quite minimal with reference to the gastro-intestinal system. Physical examination, however, had demonstrated in the abdomen a mass which was apparently related to the stomach. There was also a

definite ascites. X-ray examination localized the pathology to the gastro-intestinal system, the most marked findings being in the stomach. Microscopic examination of a rectal biopsy had demonstrated normal rectal wall, and the histology of one of the hypertrophied lymph nodes was merely that of lymphoid hyperplasia.

With these considerations in mind, but overlooking a significant blood picture because of insufficient co-ordination, a preoperative clinical diagnosis was made of probable polyposis of the stomach, with carcinomatous degeneration. The condition of malignancy was included because of the presence of ascites.

Therapy.—Operation was performed under spinal anesthesia on June 22, 1929, by Dr. O. H. Wangensteen. A high, right rectus incision was made and when the abdomen was opened the stomach was found to be tremendously dilated and apparently filled with small tumors (Fig. 3). Its external appearance was lobular and the vessels of the submucous coat shone through around the periphery of what appeared to be a solid mass within the stomach. The enlargement within the stomach extended directly up into the cardiac portion.

The first and second portions of the duodenum were tremendously distended and also contained large tumor masses (Fig. 4). The retroperitoneal portion of the duodenum was not examined. From the duodenojejunal juncture down to the cecum the entire small bowel was punctated here and

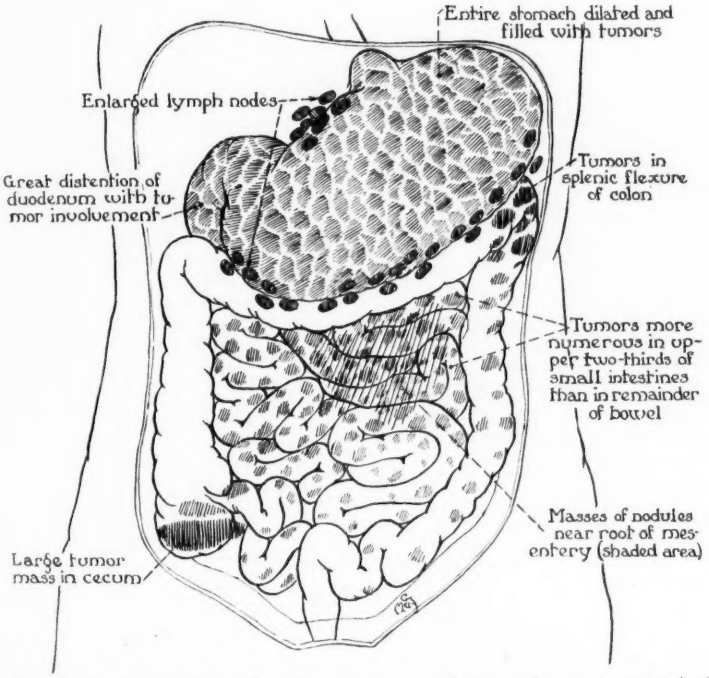

Fig. 4. A sketch, illustrating the appearance of the entire gastro-intestinal tract *in situ*. The stomach is shown to be dilated and its wall infiltrated with small tumors. The paragastric lymph nodes are enlarged. The duodenum is also infiltrated with small tumors and greatly distended. The entire small bowel is punctated here and there by small tumors. There is a large cigar-shaped tumor mass in the cecum. Scattered tumor infiltrations are present in the region of the splenic flexure and descending portions of the large bowel.

there by small tumors, varying in size, many of which were adherent to the bowel wall. In the cecum there was a large, cigar-shaped tumor mass which seemed to extend through the bowel wall and into the parietes of the right lower quadrant. It was considered possible that this tumor outside the bowel might be lymphoid tissue. The location of the incision prevented this differentiation, but on palpation it seemed to be one continuous mass. It was thought that the tumors were much more prevalent in the upper two-thirds of the small intestine than in the lower one-third (Fig. 5).

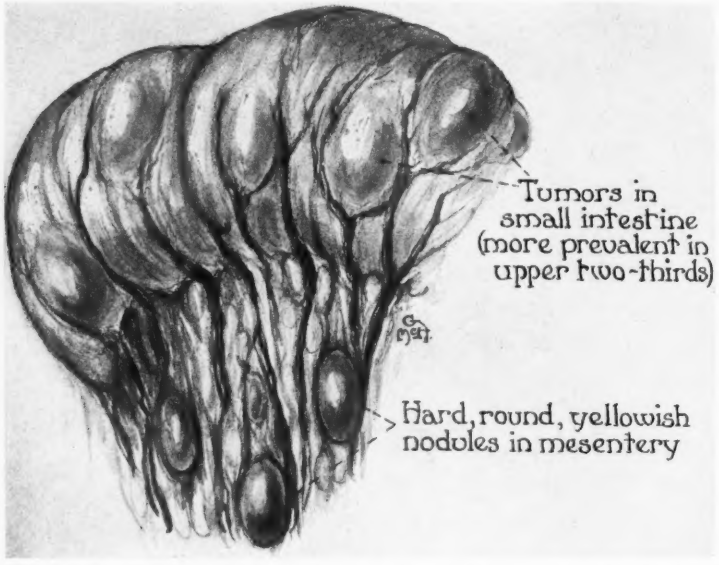

Fig. 5. A sketch, illustrating the marked tumor infiltration in the upper two-thirds of the small intestine. A few nodules are present in the mesentery.

There were three or four similar nodules in the splenic flexure of the colon and a few in the descending colon. The nodules were also present all along the mesentery. There were masses of nodules, many slightly yellowish in color, in the right side of the mesentery of the small intestine (Fig. 6). The spleen and liver appeared to be normal. There were a number of large lymph nodes along the greater and lesser curvatures of the stomach. Two of them were excised, and microscopic examination demonstrated a definite lymphatic leukemia (Fig. 7).

The surgeon deemed it best to close the wound after exploration without performing a jejunostomy for feeding purposes, because of the presence of the large mass in the cecum which would undoubtedly have eventuated in obstruction before the patient could take food.

About six weeks after operation a light dosage of deep x-ray therapy was given, but the condition of the patient at no time permitted the necessary heavy dosage.

Post-operative Course.—The pulse, however, was quite rapid, ranging between 100 and 110 beats per minute. Repeated post-operative blood examinations showed a somewhat constant leukocyte count of approximately 30,000 cells. The presence of immature cell forms was not recorded. The abdominal wound failed to close well, and one month after operation there was little evidence of healing. The patient was also

considerably distended during this time. He became progressively weaker and exitus occurred on August 16, 1929. An autopsy could not be obtained.

DISCUSSION

Etiology.—The variety of lymphatic leukemia tumor manifestations, as evidenced in the preceding case report, and the rarity of the condition have minimized knowledge of the process as an entity. Consequently information regarding the condition is essentially that of lymphatic leukemia. A discussion of lymphatic leukemia deposits throughout the digestive tract necessitates mention of the inflammatory and neoplastic conceptions of the fundamental disease process. Chronologically, the first conception was that of the infectious nature and bacteriologic cause of the disease and its manifestations. Kelsch and Vaillard (22), in 1890, and Pawlowsky (32), in 1892, isolated causative organisms. Further experimentation at that time was fruitless, and Reed (36), in 1902, in summing up the literature to that date, concluded that the condition was due to some poison affecting the bone marrow.

The neoplastic nature of the disease was first advanced by Babes (1), in 1902. Senator (41) had reported transformation of certain tumors as early as 1882, but these were considered as accidental occurrences of two distinct lesions. Babes (1) was the first to consider all lymphatic leukemias and their manifestations as true neoplastic processes. Stimulated by this idea publications appeared for several years, proving the relationship of lymphatic leukemia and various forms of tumors.

Warthin's discovery (47), in 1907, of the leukemia of the common fowl resulted in the transmission of the disease through sev-

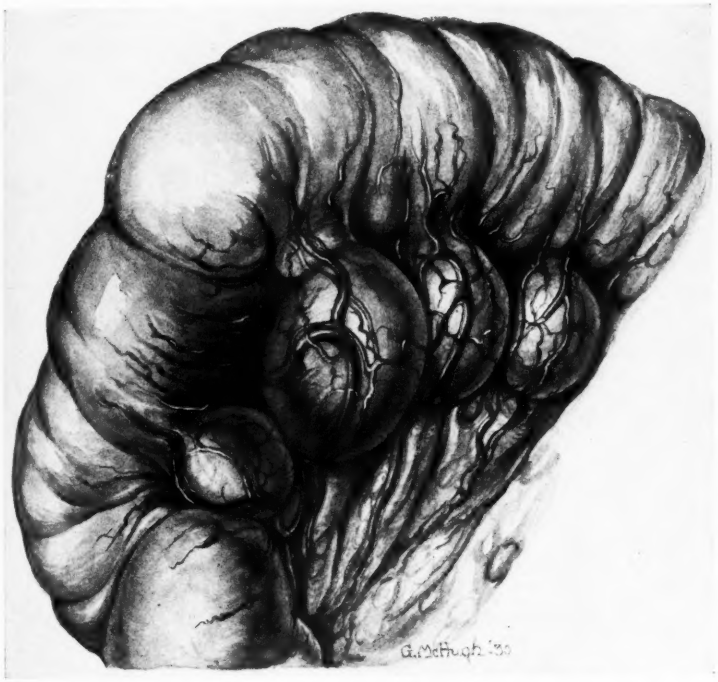

Fig. 6. A sketch, illustrating the marked invasion of portions of the mesentery by tumor infiltrations.

eral generations of the same species and weakened the purely neoplastic conception of the disease.

Most of the evidence produced within the past ten years favors the infectious theory. Nevertheless, prominent investigators, such

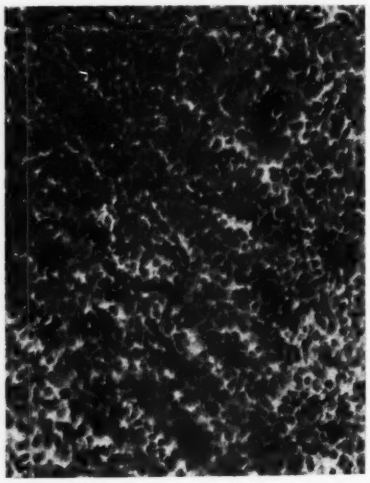

Fig. 7. A low power lens view of the typical lymphatic leukemia paragastric lymph node (× 100).

as Piney (33) and Lenaz (25), still feel that the condition is neoplastic. Ewing (10) has assumed a middle course and states that the acute forms are probably infectious and the chronic forms neoplastic.

Lymphatic Leukemia.—Although the occurrence of lymphatic leukemia lymphoblastomas is quite generally recognized, comparatively little is known about their essential pathologic, clinical, and hematologic characteristics. A study of leukemia and leukemic tumors shows that the disease process is composed of many phases of hyperplasia of lymphoid tissue. This case report presents an example of chronic lymphatic leukemia, with a pronounced hyperplastic and neoplastic phase.

Many of the manifestations of this condition are still somewhat vague, especially with reference to those of a neoplastic nature. It is known that the lesions of leukemia, both lymphocytic and myelocytic, involve bone marrow, lymph nodes, spleen, and other pre-existing lymphoid tissues. Heteroplastic growths of lymphoid tissue are seen in the liver, kidney, lung, skin, serous membranes, and many other organs. The chief location of these growths is in the liver, a certain variable distribution of lesions being practically constant in all forms of leukemia. Other organs and tissues, including the alimentary canal, are only occasionally the site of the infiltrations.

As a consequence of the extreme rarity of the condition in the digestive tract, no extensive studies of such pathologic changes have been possible. The disease process, probably essentially the same as that affecting the lymph nodes, results in involvement of chains of nodes and lymph follicles which may remain discrete or become fused. The hypertrophy of the gastro-intestinal lymphoid tissues may result in the formation of bulky tumors. The submucous lymphoid tissue may hypertrophy, with resulting discrete multinodular formations or with ulcerated lesions.

The origin of heteroplastic deposits in the digestive tract or elsewhere is not definitely known. Dominici (9) and Sternberg (43) have concluded that they arise from preexisting lymphoid structures by hyperplasia. Banti (3), however, feels that the deposits represent metastatic growths of embolic cells.

The presentation of minimal symptoms referable to the gastro-intestinal system is not uncommon in these cases. The symptoms may be merely those of general malaise and loss of appetite, with an associated progressive lymphadenopathy. In other cases the symptoms may be primarily those of gastro-intestinal pathology. In these instances the complaints usually consist of abdominal pain, with or without relation to meals, nausea and repeated emesis, the development of an abdominal mass, weakness,

and loss of weight. There may or may not be free hydrochloric acid in the stomach contents, and the stools usually do not show evidence of hemorrhage within the intestinal tract. The symptomatology of the condition is not characteristic. It is closely simulated by all of the lymphoblastomatous conditions which affect the digestive tract and cannot be differentiated from them. Furthermore, Singer (42) declares that these symptoms cannot be definitely distinguished from the variable clinical findings of carcinoma of the digestive tract.

The blood picture consists essentially of a progressive anemia and a definite leukocytosis. In the lymphatic type the leukocytic increase is composed predominantly of lymphocytes; in the myelocytic type the number of polymorphonuclear myeloid cells is increased, the cause of the large number of cells in the blood stream being obscure.

The existence of a definite lymphocytic leukocytosis would probably arouse suspicion of the presence of a lymphoblastoma of the intestinal tract. Even this finding, however, cannot be relied upon for diagnostic purposes, for Lannois and Regaud (24), Lucke (28), and Schenk (39) have reported tumors essentially different from leukemia which discharge cells into the blood and simulate it by the production of a lymphocytic or myelocytic leukocytosis.

Aleukemia.—In 1865, Cohnheim (6) applied the term "pseudoleukemia" to a condition anatomically identical with leukemia, excepting for a normal blood picture. The term "aleukemia," however, has been used in recent years in preference to pseudoleukemia. Wunderlich (50) described the condition as a peculiar disease chiefly characterized by a gradual development of numerous swellings of superficial and internal lymph nodes and by peculiar deposits in the internal organs, including the gastro-intestinal system.

Aleukemia of the digestive system was first mentioned by Briquet (4), in 1835, and fully described by Stoerk (44) and Symmers (46), who collected 10 cases from the literature. It is generally agreed that deposits in the gastro-intestinal tract are quite uncommon and that they are usually diagnosed by the pathologist. A survey of the literature by Wells and Maver (49) showed the presence of approximately 238 cases of leukemia discovered at autopsy. The gastro-intestinal tract was involved to some degree in 34 of these. The condition was confined to the stomach and intestine in 13 cases, to the stomach alone in seven, and to the intestine in 15 cases. No case of aleukemia of the gastro-intestinal tract was found by the author in a review of 16,254 autopsies performed in the Department of Pathology of the University of Minnesota in the years from 1910 through 1930.

The pathology of the condition, when involving the gastro-intestinal tract, varies from slight swelling of the mucous membrane and lymph follicles to extensive hyperplasia of the lymphoid tissue of the entire alimentary canal. There is also an associated general lymphadenopathy. The process may be limited to a portion, or involve the entire gastro-intestinal tract. When the condition involves the stomach to any appreciable extent the mucosa is thrown into great folds described as simulating cerebral convolutions. Polypoid formations in the stomach and elsewhere in the digestive tract are often present. Ulceration of the mucosa is infrequent, although perforation of a deep ulcer and peritonitis have been reported by Stoerk (44). The muscularis is uniformly uninvolved.

A normal blood picture differentiates the condition from lymphatic leukemia lymphoblastoma. Ewing (10) states that occasionally a relative lymphocytosis is observed, but no absolute leukocytosis.

Lymphogranuloma.—A group of cases formerly classed as aleukemia are now called "lymphogranuloma," or "Hodgkin's disease." The histology of the condition has

been emphasized by Reed (37), and Sternberg (43). Often the initial symptom is an enlargement of chains of lymph nodes, cervical (50 per cent) or otherwise. In from 60 to 70 per cent of cases a splenic enlargement occurs, with an associated cachexia and sharply intermittent type of fever.

Gastro-intestinal lymphogranulomatosis is a rare occurrence. Lymphogranuloma involving the digestive tract was found in three instances in 16,254 autopsies recorded in the Minnesota University Pathology Department. A recent survey (13) of approximately 80 cases of Hodgkin's disease, treated in the roentgentherapy department of the University of Minnesota Hospital, shows only one case with proved involvement of the digestive tract. Gastro-intestinal involvement had been suspected in one other case from clinical findings and symptoms, such as an intra-abdominal mass and the occurrence of gastro-intestinal upsets. Hayden and Apfelbach (14), in reviewing the subject, state that the condition had previously been reported in about 25 cases, in 12 of which the stomach was involved. Singer (42) has recently reported the first case of the condition which was primary and isolated in the stomach. The lesions are usually located in the intestine but may be found in any portion of the digestive tract. Hodgkin's disease is difficult to separate pathologically from tuberculosis (40) and lymphosarcoma (10). Coupland (7), Kaznelson (21), Singer (42), Sussig (45) and others have described typical cases but the literature is scanty, as most cases are classified with lymphosarcoma.

The pathologic picture varies from small thickened areas of mucosa to large, infiltrative, ulcerating lesions which sometime result in perforation of the bowel wall. Ulceration occurs quite frequently and, in contrast to tuberculosis, is present in the upper digestive tract. It is stated (15) that the ulcerative lesions cannot be differentiated from carcinoma except by microscopic study. Obstruction of the bowel in this condition is relatively uncommon.

The blood picture is usually normal except for a prevailing relative lymphocytosis. There is usually no leukocytosis.

The following brief report illustrates a case of this type recently encountered on the surgical service at the University of Minnesota Hospital. A white male, 67 years of age, was first admitted to the University Hospital on September 2, 1930. He complained principally of a sensation of fullness of the stomach, a mass in the region of the stomach, emesis of solid foods, constipation, a recent loss of 20 pounds in weight, and generalized weakness. These symptoms had commenced in July, 1930, and had developed more or less in the sequence listed above.

Physical examination demonstrated a firm, movable, slightly tender mass, measuring approximately 10 cm. in diameter, in the midepigastrium. The mass moved with respiration and could not be definitely separated from the liver margin. A smaller mass about 2 cm. in diameter below and to the right of the large epigastric mass was found to move freely from side to side and with the diaphragmatic excursion.

Laboratory examination of the urine and blood showed them to be normal. Gastric and stool analyses and blood chemistry tests were normal. X-ray examination of the gastro-intestinal tract favored a diagnosis of carcinoma of the stomach, although possible pressure on the stomach from an extragastric mass was considered.

With a pre-operative diagnosis of carcinoma of the stomach, exploratory laparotomy was performed by Dr. O. H. Wangensteen. The stomach and duodenum were found to be normal, but displaced upward and forward by a large mass of lymph nodes which were closely matted together. Another mass about 4 cm. in diameter, which on gross section appeared to be a

lymph node, was present in the transverse mesocolon. It was removed for histologic study. An anterior gastro-enterostomy was performed to relieve symptoms of gastric obstruction. Microscopic examination of the removed tissue resulted in a diagnosis of lymphosarcoma.

Following a stormy convalescence the patient was given deep roentgentherapy and discharged from the hospital, returning at intervals for further x-ray treatments. His general condition was fairly good until October 12, 1931, when he was again hospitalized because of recurrence of his initial symptoms and complaints. Physical examination disclosed a tender epigastric mass and enlarged inguinal lymph nodes. Laboratory examinations showed a marked secondary anemia, with a relative lymphocytosis. Death resulted from a terminal lobar pneumonia.

Necropsy was performed and a retroduodenal mass was found obstructing the first portion of the duodenum. Neither intrinsic gastric nor duodenal pathology was observed. The cecum and ascending colon showed multiple, umbilicated submucosal nodules, measuring from 1 to 2.5 cm. in diameter. All of the retroperitoneal abdominal nodes and the superficial and deep inguinal nodes were hypertrophied. The spleen was enlarged and showed multiple tumor-like infiltrations. Microscopic study of the retroduodenal mass and cecal infiltrations resulted in a final diagnosis of Hodgkin's disease, which was in distinct contrast to a previous histologic diagnosis of lymphosarcoma made one year before from an operative biopsy specimen.

The case is of interest as a relative rarity and because it is exemplary of the fallibility in diagnosis of these conditions and the sources of confusion in classification of related disease processes.

Lymphosarcoma. — Lymphosarcoma was also formerly included with aleukemia. The pathology of the condition was first clearly described by Kundrat (23); however, lymphosarcoma is now recognized as a highly malignant neoplasm arising in lymphoid tissue.

Weeden (48) concluded from a review of reported cases of lymphosarcoma of the intestinal tract that it can no longer be considered as an extremely rare occurrence. Yet it is still so uncommon that isolated case reports are constantly appearing in the literature. Lymphosarcoma involving the gastro-intestinal tract occurred in seven of 16,254 autopsies recorded in the archives of the Minnesota University Pathology Department. This indicates a higher incidence than that of other lymphoblastomatous manifestations. A complete tabulation of reported cases has not been attempted, due to the variation in terminology and because of the many cases reported with partial or no microscopic diagnoses.

The pathologic condition is described as arising from groups of lymph nodes, not single nodes, and from the adenoid tissue of mucous membranes, from which points it extends along submucous tissue or to neighboring nodes and surrounding tissues. Secondary tumors occur almost exclusively in the intestinal mucosa, serous membranes, and lymph nodes and extend by growth through lymph channels. The tumors produce bulky growths which tend to press on the bowel wall from without or result in necrosis and ulceration of mucous membranes from within. Cayley (5) and Kundrat (23) describe the gastric lesions as bulky and diffuse growths about the pylorus or curvatures, and state that it is difficult to determine whether the primary growth is in the wall of the organ or adjacent lymph nodes. They are usually part of a general lymphosarcomatosis, involving the entire gastro-intestinal tract (51). Some gastric tumors produce projecting submucous masses (20) or polypoid and pedunculated formations (34). Ulceration and

pyloric stenosis are frequent. In the intestine the tumors are most common in the lower ileum but may appear at any point. Rectal (11) tumors are the least frequent. The appendix (17) may be a primary site and present an acute (26) picture. The early stages of these lesions appear as thickenings of the submucosa with or without ulceration. Polypoid growths and subserous tumors appear later. Ulceration, perforation, and peritonitis may occur.

The blood picture is usually normal except for polymorphonuclear neutrophilic leukocytosis which is usually present. Occasionally the picture resembles leukemia, and the differentiation between these conditions cannot always be sharply drawn (29).

The preceding brief survey of the salient characteristics of lymphoblastomas affecting the gastro-intestinal tract emphasizes their marked similarity. Their occurrence, excepting lymphosarcoma, has been so infrequent in the literature that further recording of isolated cases may be considered justifiable. Since lymphosarcoma may no longer be considered a rarity among lesions of the gastro-intestinal tract, it may consequently assume an important diagnostic significance. Notwithstanding the stated infrequency of occurrence of lymphoblastomas of the digestive tract, more than 250 cases have been reported (12). Furthermore, they are considered to be the most common tumors of the small intestine (27), occurring three times as often as carcinoma. Consequently, these lesions deserve constant consideration in the differential diagnosis of tumors of the alimentary canal.

The gross pathologic[1] appearance of these conditions suggests that they are essentially normal variations of a fundamental disease process. The symptomatology of lymphoblastomas of the digestive tract is not characteristic. The symptoms do not permit accurate and constant differentiation (15) of the condition from carcinoma or other tumor formations of the gastro-intestinal tract. Therefore, it may be concluded that the symptoms are simply those of gastro-intestinal neoplastic processes.

The hematologic findings in these allied conditions tend to show some differential points. Yet it is stated (10) for each of the conditions that there are occasions when no clear hematologic demarcation is possible. Furthermore, there are accumulating records of neoplastic processes, such as carcinoma of the uterus (24), spindle cell sarcoma of the axilla (28), and carcinoma of the stomach (39), which have produced blood pictures paralleling those of the lymphoblastomas. This would suggest a non-specific reticulo-endothelial reaction to neoplasms in general.

It is clear that the differential diagnosis of these conditions cannot be made with assurance upon a basis of clinical findings. The development of roentgenographic examination of the body has been of inestimable aid in general diagnosis. Holmes, Dresser, and Camp (15), Junghagen (18), and Ruggles and Stone (38), agree from their studies, however, that roentgenologic aid in the accurate differential diagnosis of lymphoblastomas of the alimentary canal has been minimal, for most of the lesions have been diagnosed as carcinoma. They have rarely been correctly diagnosed roentgenologically, and only after careful study of the clinical and laboratory findings. The failure in diagnosis of the condition is probably due to the fact that most roentgenologists see only one or a few isolated cases. More extensive roentgenologic experience with the condition will no doubt result in more general recognition of it.

Treatment.—Minot and Isaacs' (31) extensive analysis of results of treatment of lymphoblastomas in general, by surgery

[1]The author is indebted to Dr. E. T. Bell and Dr. W. A. O'Brien, of the University of Minnesota Pathology Department, for confirmation of statements and opinions concerning the gross pathology of the conditions described.

and irradiation, shows that the results of surgery alone are better than irradiation alone, and that the greatest therapeutic benefit is derived from a combination of these methods. Evaluation of methods of treatment of lymphoblastomas of the digestive tract must, necessarily, be based upon the results derived from the treatment of the most common type of lesion encountered, namely, lymphosarcoma. The literature in this regard indicates that treatment has been primarily surgical, irradiation being secondary. The diagnosis of the condition has usually been inaccurate, practically every case being considered carcinoma; consequently, surgical treatment has been employed. Furthermore, in many cases the diagnosis has not been clear and surgery has been utilized as a diagnostic procedure. For these reasons surgical therapy has predominated. When the true nature of the condition has been recognized, however, roentgentherapy has been recommended almost invariably as a secondary therapeutic measure.

These considerations must separate a very small group of cases, in which the diagnosis is made pre-operatively and the tumor is apparently resectable, from a much larger group of cases in which the diagnosis is made only at operation. Crumston (8), Rankin (35), and Weeden (48) state that opinion regarding treatment of the first group is not unanimous, but that surgical excision of the lesions is most frequently recommended. There is practically unanimity of opinion that surgical resection should be performed in the second and larger group of cases. It is generally agreed that roentgentherapy post-operatively is constantly valuable.

No detailed analysis of the results of treatment of leukemia, aleukemia or Hodgkin's disease of the intestinal tract has been possible because of the relative rarity of these cases in the literature. Lymphosarcoma, however, has been more frequently encountered among neoplasms of the digestive system, and some specific data regarding results of treatment have been obtained. Liu (27) reported 12 cases involving the small intestine, with no immediate operative mortality. Five cases died three months post-operatively, four cases lived from 1.5 to 6 years after operation, and three cases were living five years after operation, without recurrences. Weeden (48) reported 10 cases with involvement of the small intestine, seven of which died within one year after operation, one within 2.5 years, and one within 3.5 years after operation.

Kapel (19) collected and reported a series of 60 cases of lymphosarcoma of the stomach. Resection was performed, with an immediate mortality of 18 per cent. He reported three cases of the group living 8, 9, and 15 years post-operatively, without recurrences. Minot and Isaacs (31) reported lymphosarcoma of the stomach, in one case, that lived seven years after operation, and Weeden (48) reported one case with involvement of the stomach, that was well nine years after gastric resection. Balfour and McCann (2) reported sarcoma of the stomach in 54 cases, 32 of which were lymphosarcoma. Fifty-three of the cases were operated upon, with an immediate mortality of 11.3 per cent. Direct operative procedures upon the stomach in 38 cases resulted in a 13.5 per cent immediate mortality. The average post-operative length of life after simple abdominal exploration was four months, and after gastric resection, 11 months. Twelve cases were reported to be living five years, and one case nine years after operation, with no clinical evidences of recurrence.

The results of surgical treatment of lymphosarcoma of the gastro-intestinal tract are encouraging. One may conclude that surgical treatment is justified for the various types of lymphoblastomas of the digestive system.

SUMMARY AND CONCLUSIONS

1. Chronic lymphatic leukemia involving the gastro-intestinal tract occurs very infrequently.

2. All tumors of the digestive tract arising in lymphoid tissue are relatively rare occurrences. Lymphosarcoma is the most frequently encountered tumor of this group.

3. Comparisons of the gastro-intestinal manifestations of leukemia, aleukemia, lymphogranulomatosis, and lymphosarcomatosis show a marked clinical, pathologic, and hematologic similarity.

4. None of the diagnostic features of these conditions is characteristic. Because these conditions usually cannot be differentiated from carcinoma of the intestinal tract, they assume an important differential diagnostic significance.

5. Accurate diagnosis depends principally upon a careful correlation of the clinical, x-ray, and laboratory findings.

6. The combination of surgical treatment and roentgentherapy has been shown to offer the greatest therapeutic benefit in the treatment of lymphoblastomas in general.

7. Intestinal resection, in a small series of cases, has shown no immediate operative mortality. Gastric resection, in two relatively small series of cases, has shown an immediate operative mortality of approximately 15 per cent.

8. The average duration of life after gastro-intestinal resection has been approximately one year; however, a considerable number of five-year cures have been reported. Isolated cases are reported living as long as eight, nine, and 15 years after operation, without recurrences.

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PROGRESS IN THE DESIGN AND MANUFACTURE OF X-RAY TUBES

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THE purpose of this paper is to present some of the factors that have been of importance in recent x-ray tube design and manufacture. To some extent it is a survey of the present status of knowledge about x-ray tubes, with particular reference to progress of the last few years and factors not generally understood. In the attempt to explain, briefly, involved problems in the field of physics and engineering, a certain lack of clarity in some cases is probably unavoidable. If, however, enough clearness can be obtained to convey any appreciable amount of stimulation or value the paper will have served its function.

PART I. DESIGN

1. Physical Dimensions

The dimensions of an x-ray tube are determined largely by the voltage at which it is to be operated. Provision must be made

for the high electrostatic stresses accompanying the voltage, and also for the high velocity electrons made possible by the high voltage and essential in the production of x-rays. It is significant that high velocity electrons are sought deliberately in no other vacuum device, with the exception of the cathode ray tube. Hence, x-ray tubes present problems not found in other vacuum devices. The electrons must be accelerated, focussed, stopped, and resultant heat dissipated. In hitting the focal spot many are not completely stopped, but bounce off with a lower velocity to be attracted to other portions of the tube, such as the envelope, anode shank, and anode arm.

The conventional shape of the hot cathode x-ray tube envelope is a spherical bulb having two cylindrical extensions called the anode and the cathode arm (Fig. 1-*A*).

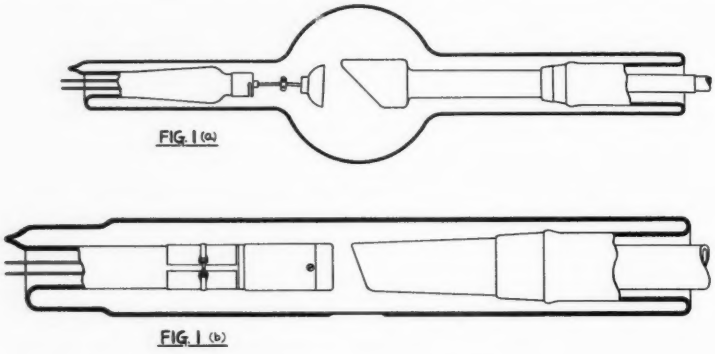

Fig. 1. Comparative drawings of two types of diagnostic x-ray tubes. *(A)* Soft glass tube, rated 85 K.V.P., tested at 110 K.V.P., used with lead glass bowl for x-ray protection. *(B)* Hard glass tube, rated 110 K.V.P., tested at 130 K.V.P., used with cover shown in Figure 2 for x-ray protection.

TABLE I

Maximum allowable pressures of various gases for good tube operation at 85 K.V.P., 30 ma., of tube shown in Fig. 1-*A*.

Helium	5.0 to 10.0 microns
Hydrogen	4.0 to 8.0 microns
Nitrogen	0.5 to 1.0 micron
Water Vapor	0.2 to 0.5 micron
Mercury Vapor	0.01 to 0.03 micron

The arms serve the following purposes: (1) Give an overall length in conjunction with the bulb sufficient to prevent spark-over the outside of the tube; (2) give a convenient support for the electrodes; (3) prevent any appreciable number of stray electrons, or positive ions, from getting on the glass near either end of the tube.

The last purpose is very important and a consideration of it enters into almost every tube design. The inside surface of the glass envelope near each end of the tube must be relatively free from stray electrons in order to prevent rapid leakage of their negative charge to positive potential, heating of the glass, sparking over its surface, and resulting disturbances in general. This is prevented by the arms because of their relatively long length compared with the constricted space between their inside surfaces. It is possible to prevent stray electrons from getting to any portion of the envelope by means of a design in which the electrons are trapped in a hollow anode. In this case constricted arms are not necessary. Such a design, however, has found little application except for high voltages (4) since in most cases it is complicated and there is little to be gained over the usual design.

The bulb, on the other hand, with its

larger surface and greater spacing to the electrodes does the following:

1. Gives a large radiating surface for heat, which is of particular importance with a solid tungsten anode cooled by radiation through the bulb, as, for example, in the universal and air-cooled therapy tubes.

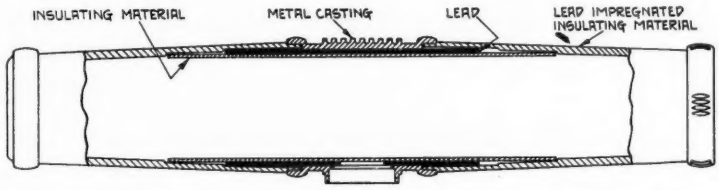

Fig. 2. Section of a removable x-ray protecting cover for tube shown in Figure 1-*B*.

2. Gives a large surface for deposit of sputtered or melted metals from the electrodes.

3. Keeps the glass out of the strongest portion of the electrostatic field between the anode and cathode so that disturbances due to high potential gradients in the glass are prevented.

A method adopted by several European manufacturers (11) for eliminating the third consideration is to make the central portion of the envelope out of metal or to shield the glass by means of metallic shields. Experiments with glass in the last few years, however, have shown that in many cases without going to this complication the size of the bulb can be made smaller than was previously thought possible. This is due, in part at least, to more heat-resistant, higher dielectric strength, hard glasses now available, such as, for instance, pyrex.

A straight cylindrical envelope, rather than a bulb plus two arms, is sometimes desirable because x-ray protection can be placed around it more readily. It has proved to be a practical shape in those cases in which by proper internal electrode design and glass selection the requirements listed under the older envelope of conventional shape are satisfied. For the purpose of analysis the cylindrical envelope can be considered as a special case of bulb plus two arms in which the arms are of the same diameter as the bulb. Its electrode design must be such that the envelope is "filled up" for a considerable distance at each end of the tube to produce the effect of constricted arms, and, on the other hand, such as to give sufficient spacing to the envelope at the central, or bulb, portion of the tube.

In the cylindrical envelope tube illustrated in Figure 1-*B* advantage is taken of the requirements as to electrode design to obtain a maximum heat capacity in the anode and x-ray protection in the cathode. The removable cover for this tube (Fig. 2) has several functions besides providing x-ray protection. Its construction is such that the tube is surrounded by an envelope of insulating material and, therefore, protected against puncture to external objects even though they are grounded and touch the outside of the cover. In case of overload and abuse of the tube, the cover allows the deposit of a greater amount of sputtered or melted metal on the glass envelope than would be the case if the tube were operated alone. The reason is that the metallic lead sleeve incorporated in the center of the cover, although primarily for x-ray protection, also acts as a condenser in conjunction with the tube electrodes to reduce longitudinal electrostatic stresses on the glass. Although without the cover these stresses would cause no harm to the glass, they might cause disturbances

over the surface of any metallic film on it, and thus seriously affect tube operation.

Electrode Spacing.—The minimum spacing between electrodes inside of an x-ray tube has been found to be a very definite function of the voltage at which the tube is to be operated. Too close a spacing results in voltage surging and erratic operation due to cold cathode discharges. Because these discharges are not focussed they are also likely to liberate gas and cause permanent injury. In general, clean, smooth, rounded surfaces stand a somewhat higher voltage for a given spacing without showing this type of disturbance.

A spacing larger than is necessary from a voltage standpoint, on the other hand, increases the difficulty of obtaining good focal spot distribution for the reason that the surrounding negatively charged envelope has a distorting influence on the electron stream, the magnitude of which increases with the electrode spacing. Also from the standpoint of x-ray protection the greater the spacing the more direct radiation must be intercepted by lead around the tube.

2. Glass

Glass is used as an insulation and envelope material in practically all partial or high vacuum tubes. The reasons for this are many: it is easily fabricated, is vacuum tight, can be degassed with relative ease, has a relatively high melting point, is a good insulator, and is transparent. There are many compositions of glass having widely different properties. The properties that are of particular importance in an x-ray tube are: high dielectric strength, high melting point, high electrical resistivity, and low x-ray absorption.

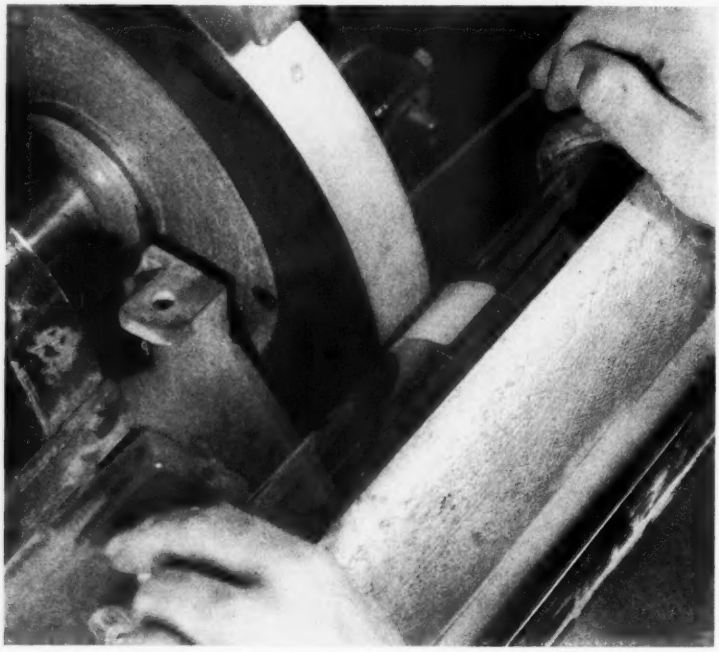

Fig. 3. Process of grinding a section of an 80-mil thick pyrex cylinder to a 15-mil thickness in order to serve as a low absorption window for x-rays.

Hard Glass.—In the past, soft glasses of sodium or cerium base have been used most frequently. Within the last few years a considerable amount of experimental work has

been done with boro-silicate hard glass. Its higher melting point, greater mechanical strength, and higher electrical resistivity than soft glass make possible, in some cases, tube designs that would be impractical with the older glass. In spite of the fact that it is more expensive and harder to work into the required shapes it is being used in most of the new tubes and is replacing soft glass in some of the older ones.

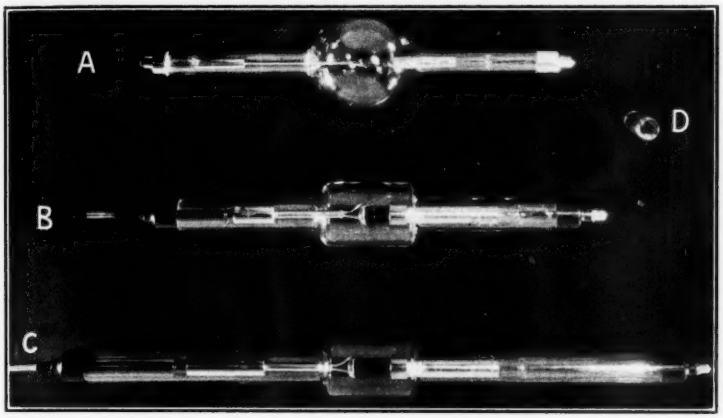

Fig. 4. Thick pyrex glass therapy tubes. *(A)* Air-cooled tube, rated 200 K.V.P., 6 ma., tested 240 K.V.P. *(B)* Water-cooled tube, rated 220 K.V.P., 30 ma., tested 250 K.V.P. *(C)* Water-cooled tube, rated 300 K.V.P., 10 ma., tested 340 K.V.P. *(D)* Cross-section of arm of therapy tube showing one-quarter inch glass thickness.

Thickness of Glass.—As has already been pointed out, in most tube designs the inside surface of the glass envelope receives a negative charge from stray electrons. Because of the charge there is a difference in potential between the inner and outer surfaces of the glass. The walls of the envelope must have sufficient dielectric strength (that is, thickness) to withstand this difference in potential which largely depends upon the voltage at which the tube is being operated. In diagnostic tubes considerations of mechanical strength and manufacture usually result in a thickness of more than enough to take care of the voltage. In one new diagnostic tube the portion of the envelope through which the useful beam of x-rays emerge is ground down to a thickness less than one-half that of the remaining portion of the envelope (Fig. 3). This is done to reduce the filtering action of the glass to a definite minimum value and at the same time obtain the ruggedness of heavier glass. In therapy tubes operating at higher voltages, however, experience has shown that in most cases the thickness must be deliberately increased or failure by puncture will occur. It has been found practical to fabricate hard glass tubes with a one-quarter inch thickness envelope (Fig. 4). Splices in the glass, bubbles, air lines, and the exhaust tubulation all have a lower dieletric strength than solid glass and must be carefully controlled. It has been found best in high voltage tubes to remove the exhaust tubulation from the center of the bulb to the cathode end of the tube.

Glass Fluorescence.—Glass, like a great many other substances when bombarded by electrons of certain velocities, gives off a glow or fluorescence of characteristic color. An analogous phenomenon is the well-known fluorescence produced on screens of calcium tungstate crystals when exposed to x-rays. Portions of the glass in an x-ray tube may

be subjected to enough bombardment by stray electrons to give a readily visible fluorescence of this kind. It is often mistaken as an indication of gas. Glow due to low pressure gaseous ionization takes place throughout the space occupied by the ionized gas and the color depends upon the gas (pink for nitrogen, blue for oxygen). Fluorescence, on the other hand, takes place only at the surface of the glass under bombardment and does not extend throughout the whole cross-section of the space, although on casual inspection this may seem to be the case. It is of a characteristic color, depending upon the composition of the glass—green for lime glass and blue for most of the hard glasses —and is most pronounced in an x-ray tube when operating at the lower voltages, such as 30 to 60 kilovolts peak. Possibly at these low voltages the amount of bombardment is greater than at higher K.V.P. because the electrons can get farther into the anode arm and thus decrease the leakage path. As a matter of fact, most tubes do not show any

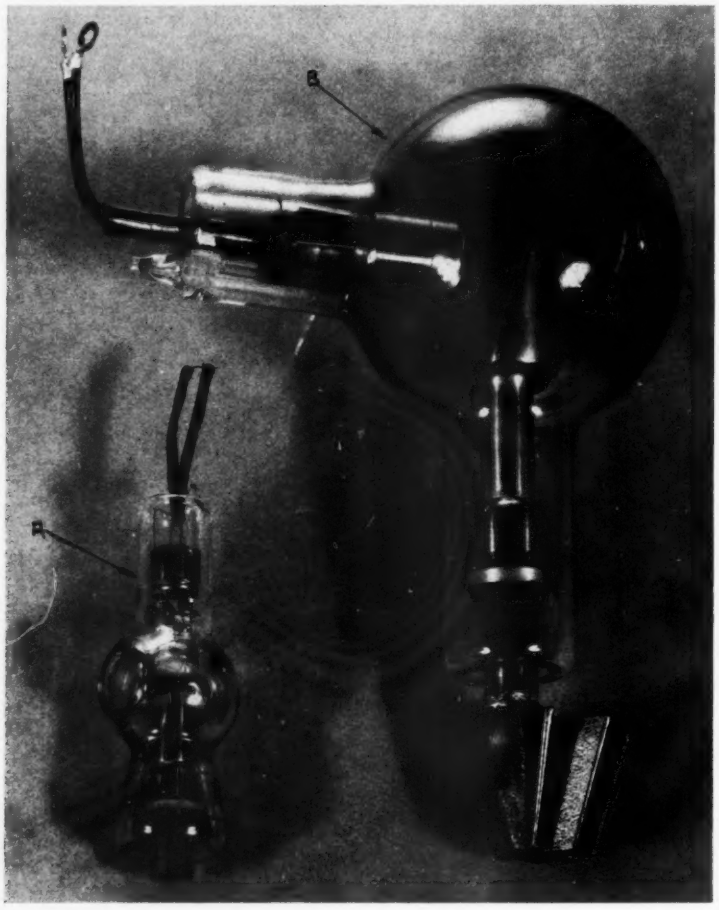

Fig. 5. Oil-immersed tubes. *(A)* Lead glass tube, rated 68 K.V.P., self-rectified, 10 ma. *(B)* Hard glass tube, rated 85 K.V.P., useful (100 K.V.P. inverse), self-rectified, 30 ma. A slightly modified form of this tube was the first tube to be manufactured in hard glass.

fluorescence at 100 K.V.P. or more, but practically every tube will show fluorescence at the lower voltages.

In itself, fluorescence does no harm. In those cases in which it is caused by high velocity electrons it may indicate and be accompanied by considerable heat which must be taken into consideration in tube design so that overheating of the glass does not occur. It is also one of the factors in oil-immersed tube design that makes possible shorter anode arm and smaller bulb construction because, with oil cooling of the glass, more fluorescence and heat can be allowed (Fig. 5).

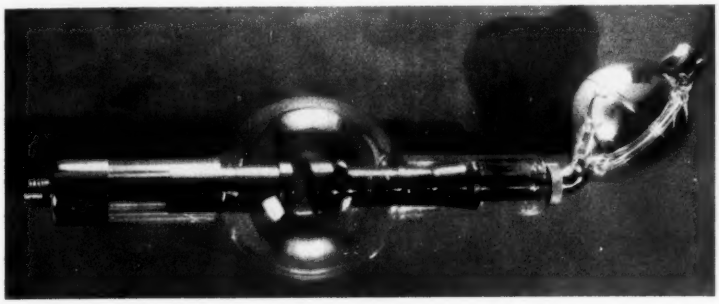

Fig. 6. Highest power radiographic tube, rated 85 K.V.P., 1,000 ma., 1/30 second or 50 K.V.P., 500 ma., 1/2 second, and capable of handling 2,000 of these exposures in one 8-hour day.

3. *Gas*

The gas pressure in a hot cathode x-ray tube must be below that which gives spontaneous or cumulative ionization (3, 6). This is necessary in order that the electron flow to the focal spot may be controlled exclusively by the temperature of the hot filament. By cumulative ionization is meant ionization which, starting with a few ionized atoms, spontaneously causes ionization of a great number. With a pressure sufficient to give cumulative ionization the electron flow cannot be controlled, and gaseous discharges between the electrodes and other parts of the tube take place with resulting runaway, additional gas liberation, glass heating, and possible failure. With a gas pressure below this critical value the flow is controllable by the filament and mainly due to pure thermionic emission, although there is always a slight amount of ionization by collision and positive ion current for the reason that a perfect vacuum is impossible to attain.

The critical pressure at which cumulative ionization starts is a function of the tube geometry, voltage that is applied to the tube, and type of gas involved. It varies between wide limits for different gasses as is shown in Table I.

In general there is no advantage to be gained by deliberately leaving a residual gas pressure. As high a vacuum as possible is desirable in order to have a margin of safety in case gas is liberated during the life of the tube. Gases such as oxygen, nitrogen, water vapor, and mercury vapor are particularly undesirable because of the instability of their action, especially in reacting with a hot filament to poison the electron emission (14).

4. *Focal Spot Considerations*

Wrought tungsten has little competition as a target material since it has to a greater extent than any other material the desirable qualities for this purpose, namely, high atomic number, high melting point, good heat conductivity, and low vapor pressure. It can be bombarded with an energy that raises its temperature to more than 2,700 degrees centigrade. This makes possible an energy of bombardment for one second of

TABLE II.—COMPARISON OF FOCAL SPOT DESIGNS WITH RESPECT TO INFLUENCE ON RADIOGRAPHIC FACTORS

All factors expressed in arbitrary units unless otherwise stated						
Focal Spot Design		Distance (of Focal Spot to Part Radiographed)	Detail (for a Given Part—Film Distance)	Radiog. Speed (*b*)	Maximum Allowable Film Dimension (*c*)	Power Required
Area of Impact (*a*)	Angle (with Respect to a Line Normal to Film)		$D=\frac{.707d}{\sin \phi \sqrt{a}}$	$s=\frac{a}{d^2}$	$L=d \tan \phi$	$p=a$
a	ø	d				
1.0	45°	1.0	1.0	1.0	1.0	1.0
4.0	45°	1.0	0.50 (poorer)	4.0 (faster)	1.0	4.0
4.0	45°	2.0	1.0	1.0	2.0	4.0
1.0	20°	1.0	2.1 (better)	1.0	0.36	1.0
4.3	20°	1.0	1.0	4.3	0.36	4.3
7.6	20°	2.75	2.1	1.0	1.0	7.6
1.0	10°	1.0	4.1 (better)	1.0	0.18	1.0
16.5	10°	1.0	1.0	16.5	0.18	16.5
33.0	10°	5.7	4.1	1.0	1.00	33.0
1.0	90°	1.0	0.71 (poorer)	1.0	large	1.0
0.5	90°	1.0	1.0	0.50 (slower)	large	0.50

(a) In all cases it is assumed that the shape of the area of impact is such that its projection on the film is a circle.

(b) It is assumed that radiographic speed is a function of area of impact and tube-part distance. This is true only for short exposures in which area of impact rather than heat conduction from the focal spot is the controlling factor in determining the maximum allowable tube power.

(c) This comparison holds assuming either that the film size is limited by difference in detail over the film or by the actual size of the useful beam of x-rays.

approximately 250 watts per square millimeter when the tungsten is in the shape of a thin 100 mill disc backed by a large copper shank of cross-section 40 to 50 times that of the focal spot area. In designs such that the focal spot area is larger in comparison with the area of copper backing the allowable energy intensity is less. For example, with a copper backing only 10 times as large as the focal spot the allowable energy input for one second is decreased to approximately 125 watts per square millimeter.

The extreme temperature changes and differences accompanying bombardment of the intensity just mentioned produce severe mechanical stresses in the tungsten. In order to minimize cracking due to these stresses the quality of the tungsten has to be carefully controlled during its manufacture (16). The severity of the stresses also increases with the size of the focal spot, so that, with large focal spots of the order of 100 square millimeters or more it is almost impossible to prevent some cracking during a reasonable life. A very fine grain or fibrous structure minimizes the cracking and prevents small cracks from spreading over a large area. This is helpful because cracks are only harmful if they distort the face of the focal spot, reduce the heat conduction, or allow copper to come through the tungsten button to the focal spot (Fig. 6).

Focal Spot Shape.—For radiographic purposes the focal spot size, shape, and angular position with respect to the film are of first importance. Along with other influences (most important of which is the part to be radiographed, its size, thickness, distance from the film, and motion) the focal spot determines such radiographic factors as film detail, tube-part distance, speed, power required, maximum allowable film size, and change in detail over the film. Table II should give a rough qualitative

idea as to how these factors are influenced by focal spot design, although interpretation of this table should be done cautiously inasmuch as its conclusions are simplified by ignoring many practical considerations.

From the table it will be noted that increase in detail without sacrifice in speed, or *vice versa,* can be obtained by changing the angle of the target face (the focal spot shape being kept such that its projection on the film is a circle or square), but not by decreasing or increasing focal spot size. On the other hand, it also will be noted that as the angular position of the focal spot is made more nearly vertical with respect to the film, the size of film that can be covered at a given tube-part distance, and with a certain allowable change in detail over the film, is rapidly diminished. In order to increase detail without changing speed, or *vice versa,* and still cover as large a film as previously possible, a smaller angle target, increased tube-part distance, and considerably increased power are necessary. Exception may occur when there is motion of the object being radiographed. In this case, increase in speed may decrease (or at least not increase) blurring on the film even though the speed theoretically is obtained at the expense of detail, that is, by increased focal spot size without change in the angle of the target or tube-part distance. In many cases in the past it has been possible to cover with a 45° target, and without noticeable distortion in detail over the film, a larger film than needed. In these cases the proper 20° anode gives better detail or speed without increase in power.

For a number of years a rotating anode target (5) theoretically has offered possibilities of allowing increased radiographic detail without sacrifice in speed. Fundamentally it involves rotation of a small focal spot with respect to the anode (and, therefore, distribution of the energy over a large area on the anode) without motion of the focal spot as far as the part to be radiographed and film are concerned. To date, mechanical complications of rotating the anode in a vacuum and conducting heat from it or of rotating the entire tube have limited and made expensive construction of a tube of this type.

No one tube or focal spot design can meet all of the situations and requirements encountered in radiographing various portions of the human body, not to mention other objects ranging from delicate flowers to 4-inch thick boiler steel. Focal spots of a number of different sizes and designs are in general use and must continue to be in use. It is outside of the scope of this paper to discuss the many complicated, and in some cases controversial, considerations that lead to a particular selection. A number of books and papers have been written on this subject (1, 2, 10, 12). As far as tube design is concerned it is sufficient to show the influences of focal spot design on radiographic factors, the resulting need for different designs, and finally, how to get them.

Cathode Design.—The problem of designing a cathode structure to give a desired focal spot size and shape is primarily a problem in electrostatics. Electrons given off by the hot cathode filament are started in the general direction of the anode by that portion of the electrostatic field (and magnetic field) immediately surrounding the filament. From then on, throughout their travel, they are accelerated in the direction of the field in which they are momentarily located. In general this field is quite complicated because of the unsymmetrical electrode shapes, the influence of charges on the envelope, and space charge. As they approach the anode their path is influenced less by the field because the velocity and momentum they have acquired resist changes in direction of motion. For this reason the field surrounding the anode does not have as much influence in determining the focal spot as that around

the cathode. The focal spot size, shape, and distribution can be controlled almost entirely by the filament size, shape, and position relative to the rest of the cathode structure (Fig. 7).

The necessity for fairly uniform distribution of energy over the focal spot makes the cathode design more difficult than otherwise would be the case. Usually the filament is mounted in a slot or opening in the cathode, and best distribution is obtained with a focal spot of about the same dimensions as this opening. It is possible to obtain, however, a focal spot either smaller or larger than the slot in which the filament is mounted by varying the depth of the filament in its slot, by varying the shape and size of the cathode around the slot (the so-called focussing cup), or by insulating the filament from the surrounding cathode and giving them different potentials (13).

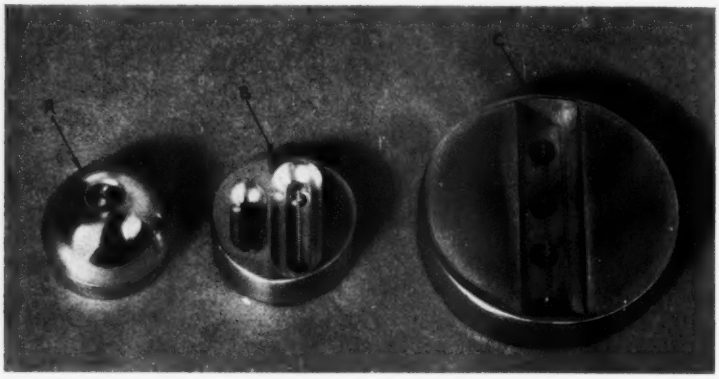

Fig. 7. Illustrations of cathode design. *(A)* Round focus therapy cathode. *(B)* Double elongated focus diagnostic tube cathode. *(C)* High power, 1,000 ma. tube cathode.

PART II. MANUFACTURE

1. Assembly and Exhaust

X-ray tube manufacture centers around the degassing and exhaust of the tube and its various parts. In no other vacuum device are the requirements so severe as to degree of vacuum and its maintenance under unfavorable conditions of heating and electron bombardment.

Sources of gas that must be eliminated during manufacture, in addition to merely pumping out the gas occupying space in the tube, are:

1. Liquids and solids, especially organic, of low melting point or unstable composition. This includes water, mercury, and all oils and greases. These substances either have a relatively high vapor pressure or are potential sources of gas at the temperatures which may be reached.

2. Absorbed gas. All solid materials normally contain more or less absorbed gas which may be liberated, to some extent at least, on heating of the material.

3. Adsorbed gas, that is, surface films of gas. All solid materials also normally attract a very thin film of so-called "adsorbed gas" on their surface which can be eliminated in a vacuum by high temperature.

Processes for eliminating these sources of gas depend for their effectiveness upon heat applied either in a vacuum or reducing atmosphere of hydrogen, and upon extreme cleanliness. Heat processes in common use are vacuum melting, hydrogen firing, high frequency vacuum firing, vacuum bake out of

glass at from 400 to 500 degrees centigrade, and, in the assembled tube on exhaust, operation as an x-ray tube with consequent heating of the cathode, anode, and various portions of the glass. Additional precautions in cleanliness involve the use of distilled water and distilled alcohol, white gloves for handling parts, hot boxes for temporarily storing parts, and nitrogen and liquid air for preventing oxidation during glass-blowing work.

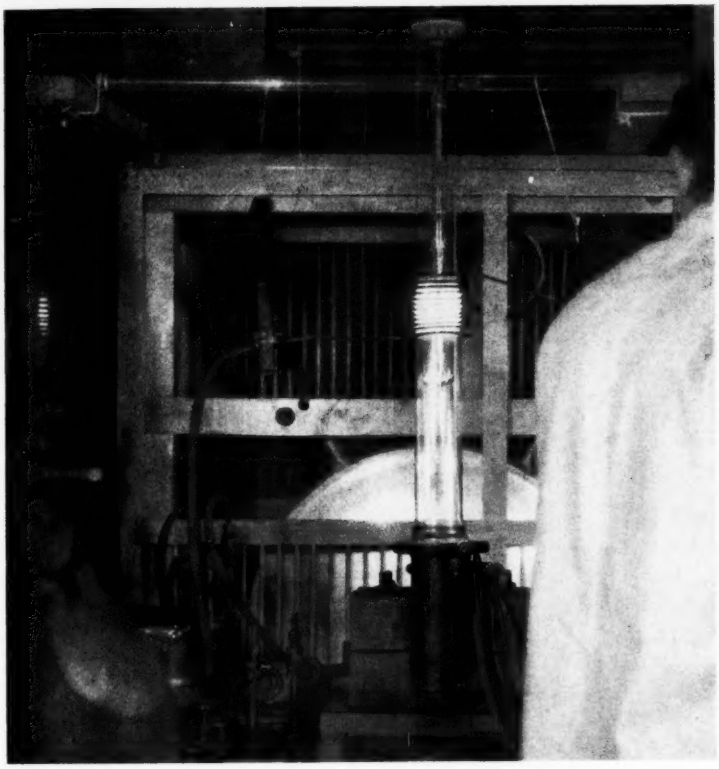

Fig. 8. Process of heating by high frequency current a therapy tube anode.

High frequency heating is used during exhaust to degas parts of the tube that adequately could be heated in no other manner. In this method of heating, energy at radio frequency (wave length from 100 to 1,000 meters) is transferred by induction or radiation from a coil around the outside of the tube to the metal electrodes inside the tube (Fig. 8). Many of the newer tubes are being designed with high frequency heating in mind and would be difficult to exhaust without it.

For many years exhaust was more or less an art because of the lack of any satisfactory simple measuring device for the order of pressures involved, and more important yet, any measuring device for the degree of degassing. With a fast pumping system a tube might be exhausted to a very low pressure but be very poorly degassed; that is, if it were removed from the pump its pressure would gradually rise to a prohibitive value. Two tools, the ionization gauge and mercury shut-off, have done much to make exhaust a more exactly measurable process (Fig. 9).

The ionization gauge (8, 15) is a sensitive instrument for the measurement of gas

pressures of the order of magnitude necessary in an x-ray tube, and is simple and practical enough to be used on every production exhaust system. It has made possible the important advance of exhaust system, heat all its parts hotter than they should become in actual operation, note the resulting increase in gas pressure, and then be able to continue the exhaust process if the test is not satisfactory.

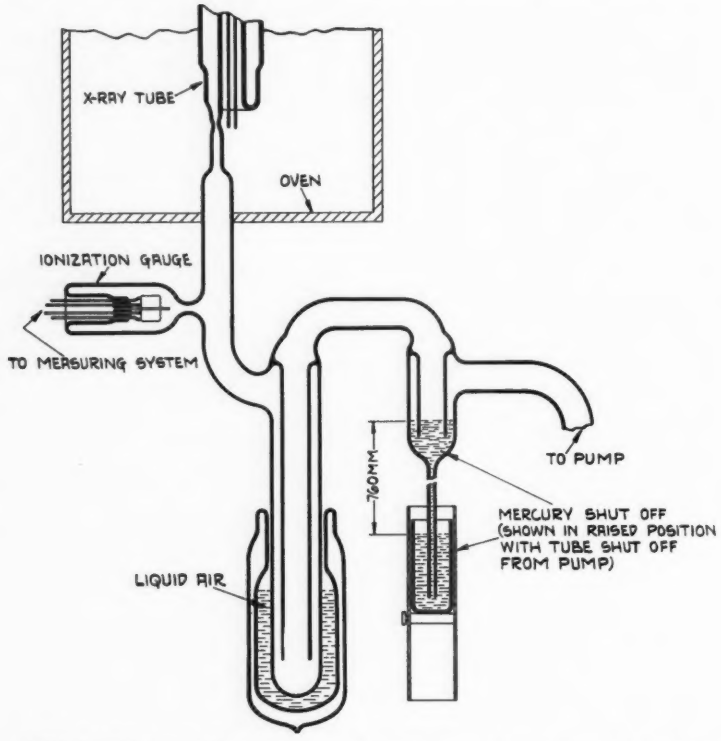

Fig. 9. Schematic diagram of an exhaust system showing ionization gauge, liquid air trap, and mercury shut-off.

schedules based on pressures instead of upon appearance and time.

The mercury shut-off is a simple arrangement in the exhaust system allowing the x-ray tube to be quickly and temporarily shut off from the pump. In connection with the ionization gauge it makes possible the testing of a tube for completeness of degassing before the tube is disconnected permanently from the pump and while there is still a pressure indicating instrument on the tube. The importance of this cannot be too greatly emphasized, that is, of being able to temporarily disconnect a tube from its exhaust

There have been other improvements in exhaust technic (*7*). Pumping systems are in general much faster than they were a few years ago. Liquid air is used as a cooling medium to insure complete condensation of water and mercury vapor. Hard glass can be baked out at a higher temperature than the earlier soft glasses (500° centigrade as compared to 400°) and consequently can be more thoroughly degassed.

2. Production Tests

No processes of manufacture are more important than the final ones of inspection and test. The best production tests are those

in which the tube is operated at higher energy and higher voltage than its rating. These overload tests insure a factor of safety that is essential to good tube operation under the varying conditions that may be met and to take care of errors in measurement of K.V.P., ma., and time. In addition, they give an opportunity of discovering defects in a short time that might not be apparent for a long time at normal operation. The following outline gives a general idea of the routine production tests that have been found desirable for diagnostic tubes:

1. Gas tests while the tube is still on exhaust. The importance of being able to test the thoroughness of degassing before the tube is taken off exhaust permanently has already been discussed.
2. Inspection for mechanical defects.
3. Filament volt-ampere test—insures that the filament will operate within specified limits of voltage and current.
4. Focal spot pictures on every tube—insures that the focal spot size is within specified limits and that the energy distribution is good.
5. Anode overload test at 120 per cent or more of rated energy insures a safety factor in the rated energy.
6. Cathode overload test—filament operated above maximum rating for a long period of time (30 minutes)—insures a thoroughly degassed cathode structure.
7. Focal spot load test insures proper operation of the tube at high energy short time exposures.
8. Over-voltage test at 120 per cent rated voltage insures a safety factor in rated voltage.
9. Milliamperage drop test, given a minimum of 24 hours after the preceding test, insures against leaks and the presence of certain gases that poison tungsten electron emission and cause an appreciable change in milliamperage during a long exposure.
10. Second inspection for mechanical defects.
11. Test immediately before shipment of tube. In general a tube should be kept in stock for at least two weeks. This insures against very slow leaks that may not have shown up on the first leak test.
12. Final inspection.

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NEW METHODS FOR THE DETERMINATION OF HIGH POTENTIALS AND HIGH POTENTIAL WAVE FORMS

By PAUL KIRKPATRICK, Associate Professor of Physics, Stanford University, California

As has been remarked more than once, the advancement of the science of medical radiology requires a general realization of the importance of precise and quantitative measurement. It equally requires, be it also remarked, the further development of means for the performance of these precise measurements. Some of the measurables concerned have been particularly refractory. Many schemes have been proposed for the measurement of high potentials, yet this important operation is still far from standardized, either in the laboratory of the roentgenologist or in other scientific or technologic fields.

The present paper contributes a description of an instrument, thought to be novel in principle, which was originated for the measurement of high voltages in the physical laboratory. The interest shown in the device by roentgenologists prompts this presentation of some applications to the medical field. While the instrument to be described is not at present commercially available, it is relatively simple in construction, and it is probable that experimenters will be able to adapt its principles to their own purposes.

The central feature to be introduced here is the instrument pictured in Figures 1 and 2 and referred to hereafter as the rotary voltmeter. In elucidating the operation of this device the diagrammatic representation of Figure 3 will perhaps be more serviceable than the photographs. In this diagram A and A' designate two insulated conductors, electrically connected to the respective terminals of the source of high potential to be investigated. For the present, suppose this potential to be direct and constant, so that a steady potential difference, V, exists between A and A'. Between these two terminals is mounted a metal cylinder, which appears in cross-section in the figure. The cylinder is split longitudinally, the halves being held rigidly together by insulating material and electrically joined only through the conductor R. Means are provided for causing uniform rotation of the cylinder about its own axis, as shown by the arrow.

It is evident that as the cylinder turns, bringing its upper half nearer to the positively charged terminal, a negative charge will be drawn to this semi-cylinder, the opposite one becoming positive, and the combined process resulting in the flow of an electric current through R. The charges on the semi-cylinders attain their maxima when the plane along which the cylinder is divided is vertical, and if the rotation continues past this position the semi-cylinders will begin to discharge and then to build up charges of reversed sign. Continuous rotation thus produces an alternating current in R, a current whose average absolute value, I, is related in a very direct manner to the potential difference V.

To render this induced current measurable and simultaneously to rectify it, the simple commutator and brush system of Figure 4 is added. This figure also includes the direct current galvanometer or microammeter necessary for the current measurement. Simple theoretical considerations and numerous experiments have shown the relation $V = I/2\ Cn$ to subsist between the applied voltage, the generated current, the number of revolutions per second, n, and a capacitance, C, characteristic of the high potential terminals and the cylinder. The electrical quantities are in practical units. The capacitance C is constant and measurable, and the constancy of n is insured by the use of a synchronous driving motor. The measurement of the applied high po-

tential thus becomes merely a matter of measuring a small direct current in a circuit which is at or near to ground potential, the relation between the voltage and current being conveniently linear.

The essential parts described above may be identified in Figures 1 and 2, in their shielding metallic box. This model was built for use with potentials up to 110 kilovolts. Extension of this range upward would require only increasing the clearances between the high potential terminals and the cylinder, so as to preclude sparking at these gaps.

The equation which describes the performance of voltmeters of this type and which was given above has been found applicable over the extremely wide range of voltages covered by the graph of Figure 5. The logarithms of applied voltages and generated currents have been plotted here, rather than the quantities themselves, because of the wide distribution of the data. Either method would serve to display the linear relationship existing between these quantities, and direct measurements of the voltmeter capacitances confirm the working equation $V = I/2\ Cn$ in detail. Such confirmation is of some practical importance since it permits us to establish the calibration of these instruments in what may be called a semi-absolute manner, that is by simple measurements which do not involve comparison with spark gaps, spectrum measurements or any other system for measuring high potentials.

In using the voltmeter pictured in the first two figures in the physical laboratory we have ordinarily preferred to measure the generated currents with a d'Arsonval galvanometer, but a switchboard microammeter of the pointer type may be used equally well and would often be found more convenient, particularly if calibrated to read kilovolts directly and perhaps furnished with shunts to cover different voltage ranges.

If the potentials to be measured are not constant but periodically variable, as are the

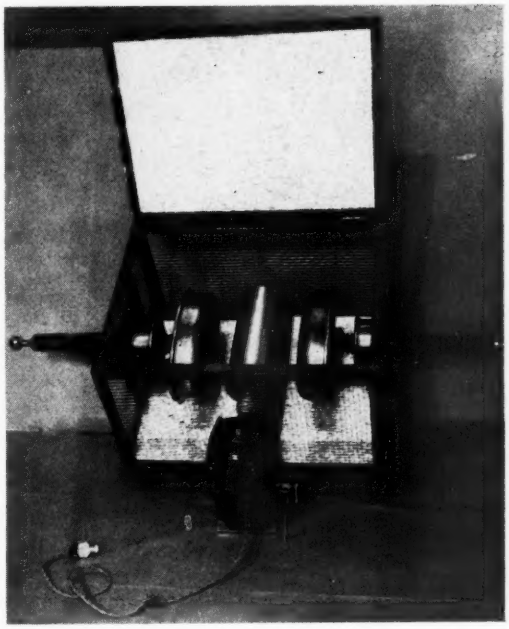

Fig. 1. Rotary voltmeter for high potential measurement. Complete except for galvanometer.

potentials delivered by the ordinary synchronous rectifier and by tube-rectified power plants when condensers are not present, the current generated by the rotary voltmeter depends upon the phase relationships subsisting between the revolution of the rotor and the variations of the applied potential. More specifically, the generated current is proportional to that particular and recurrent value of the applied voltage which obtains at the instant when the semi-cylinders of the rotor are most closely presented to the high potential terminals. If provision be made for varying this phase relationship, the whole voltage wave may be plotted out in a point-to-point manner.

This may be done in a variety of ways. In obtaining the wave forms accompanying this paper, it was done by using a phase-shifting transformer to furnish the current required for operating the synchronous motor. This method is quite convenient and allows all operations to be carried out at a

location remote from the high voltage if desired. The phase-shifting transformer, a device familiar to electrical engineers, furnishes secondary current which may be adjusted at will to make any desired phase angle with the voltage applied to its primary. Any adjustment of this transformer, therefore, advances or retards the synchronous motor correspondingly. In determining a wave form, points may be plotted as closely as desired. To obtain each point it is necessary to record simultaneous observations of the phase-angle scale of the transformer and the galvanometer or microammeter which measures the generated current. Points may be plotted at a rate of half a dozen or more per minute.

The wave forms of Figures 6 to 10 are presented as samples of what may be done by this method. They are of little interest in themselves but suggest a number of applications for apparatus of this kind. These curves present voltage wave forms, taken at the x-ray tube, for a variety of different load and line conditions. Abscissas represent time, the units being electrical degrees of the alternating current supplied to the primary of the high potential transformer, of which 360 occupy one-sixtieth of a second. The relative phases of the curves are arbitrary and without significance. Figure 6 shows the potential difference across a Coolidge x-ray tube which was connected directly to the high tension terminals of the

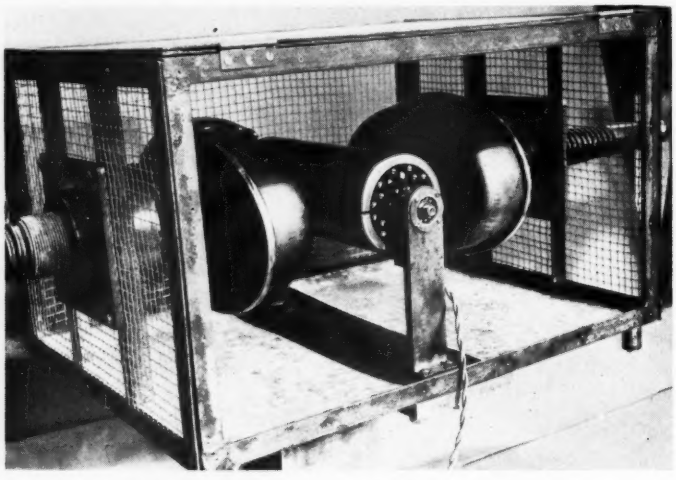

Fig. 2. Detailed view of rotor and poles.

Fig. 3. Diagram to illustrate generation of current in the rotary voltmeter.

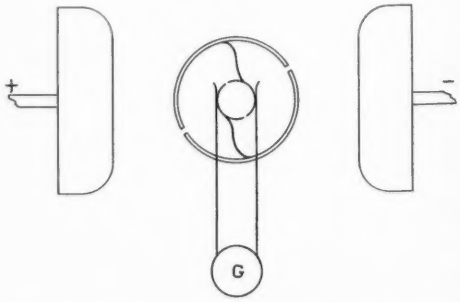

Fig. 4. Diagram of the essentials of the rotary voltmeter.

transformer, and carried an average current of three milliamperes. The active half cycle is represented in the figure by the upper half wave. It is noticeable that the inverse peak potential is distinctly higher than that of the active half cycle and that the form of the active half shows the distortion from a sinusoidal form which results from the

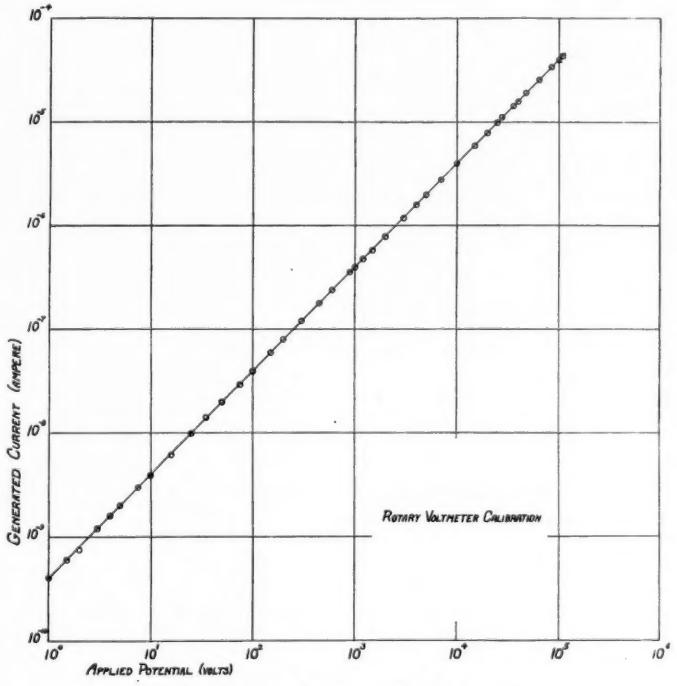

Fig. 5. Rotary voltmeter calibration curve.

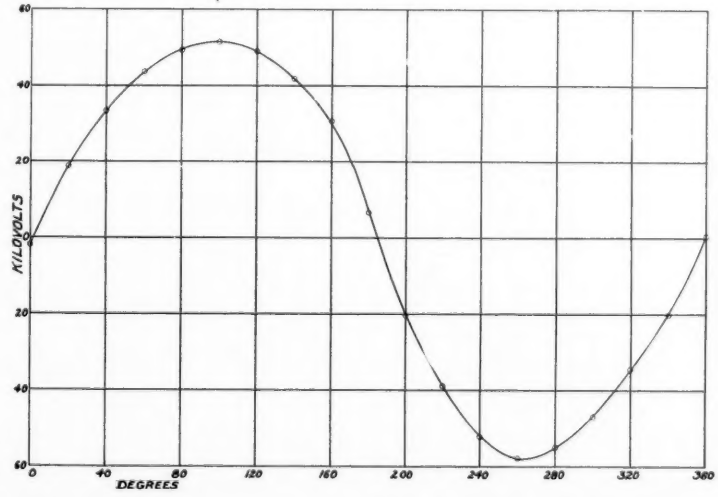

Fig. 6. Wave form of the potential difference across a Coolidge tube connected directly to the secondary terminals of a high tension transformer.

varying potential drop across the resistances of the line and the transformer.

In Figure 7 kenotrons have been inserted on each side of the tube, so that the potential across the latter can not have negative values. The fact that it does not even decline to zero during the idle half cycle is evidence of an appreciable capacitance in the line and voltmeters. The potential rises to its maximum along a smooth and approximately sinusoidal curve and then declines along a straight line as the condensed

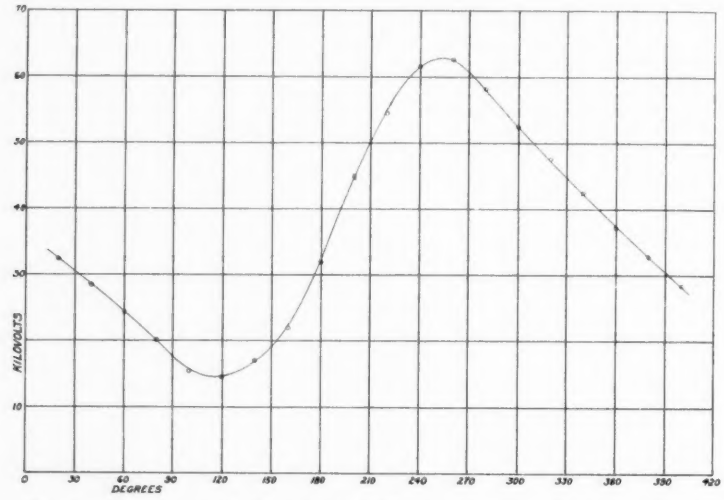

Fig. 7. Wave form of the potential difference across a Coolidge tube connected in series between two kenotrons.

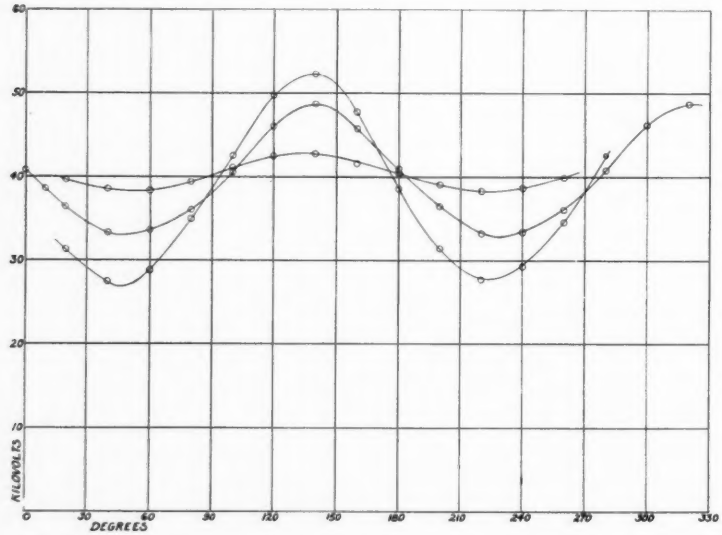

Fig. 8. Wave forms of the potential difference across a Coolidge tube supplied by a four-kenotron set producing full-wave rectification.

charges escape through the tube. The slope of this line indicates a capacitance of 0.00074 microfarad.

milliamperes. The effect of load current upon ripple is clearly demonstrated.

The curves of Figure 9 differ from those

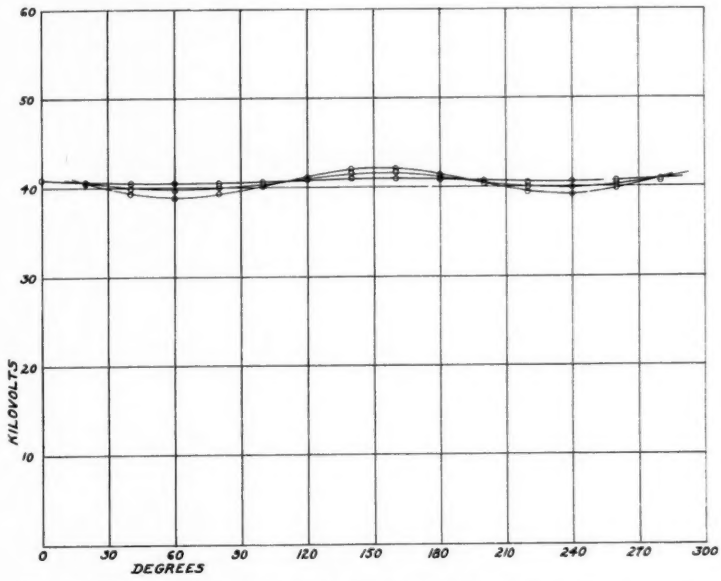

Fig. 9. Wave forms obtained under conditions like those of Figure 8 except for the addition of capacitance in parallel with the tube.

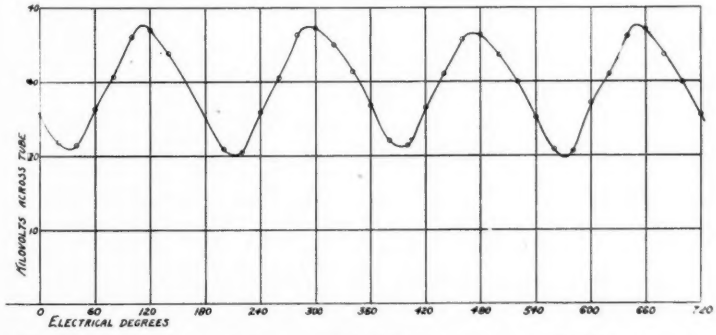

Fig. 10. Wave form of the potential difference across a Coolidge tube supplied with synchronous-rectified potential.

Figure 8 was obtained by the use of four kenotrons so connected as to effect full wave rectification. Again the line capacitance was sufficient to smooth the voltage variations quite appreciably. The three curves of this figure are for three different values of tube current, *viz.*, one, four, and eight

of the preceding figure only in that several large plate glass condensers were connected across the tube, very much augmenting the smoothing action of the line and instrument capacitances. The one-milliampere curve of Figure 9 has a ripple of only 2 per cent and approximates to constant potential. The

abruptly peaked curve of Figure 10 was secured while the tube was being operated from a synchronous rectified set without smoothing condensers.

A summary of the chief characteristics of the rotary voltmeter is presented here in conclusion. This is a strictly portable instrument, which is not deranged by handling and which requires no levelling or other adjustment when set up for operation. The range extends from a fraction of one volt to the highest obtainable potentials. The meter is accurate to a small fraction of one per cent. The indicating unit of the instrument ordinarily has a linear scale and a short period. It is kept at ground potential and may be located at any distance from the high voltage circuits. The range of the meter may be instantly changed by shunting the indicating galvanometer or microammeter. The calibration is readily established by simple low voltage operations, and this calibration remains constant. Errors due to temperature variations are negligible. The meter draws no current from the high voltage source. It is equally suitable for the measurement of constant and of periodic potentials, and in the latter case an auxiliary transformer converts the voltmeter into an instrument for plotting high potential wave forms.

The reader who wishes to consider the rotary voltmeter further is referred to two papers (1) on this subject, where many points touched upon above are more fully elaborated.

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TREATMENT BY RADIATION OF CANCERS OF SKIN, LIP AND BREAST[1]

END-RESULTS THREE YEARS LATER OF CASES PRESENTED IN 1929

By BARBARA HUNT, M.D., BANGOR, MAINE

MY intention is to carry on the report[2] given at the Toronto meeting, in 1929, bringing it up to date so far as the number of deaths is concerned. The interest in this small group of cases seems to lie in the experiences gained in an intimate relationship between radiologist and patient during a period of ten years.

CANCER OF THE SKIN

In my previous paper I reported 279 cases treated between 1922 and 1929, with 24 deaths from cancer and 197 cases free of the apparent disease. Of the latter, three have since succumbed to recurrences.

The simplicity of our treatment seems pleasing to the patient, involving as it does no pain or discomfort, only a few hours' stay in the office chair, and six weeks of moderate scabbing to which no treatment or dressings are applied. The patient is advised to leave the treated area severely alone, exposed to the air, and to keep it as dry as possible. Occasionally at the first inspection after the final scab has dropped off, a second smaller treatment is required for some heaped-up spot on the edge which failed to receive sufficient radiation through slipping of the protective shield or too small a window. Rarely, it is evident, at the end of six weeks, by some induration or appearance varying from the usual, that the original dose was not heavy enough. In such a case,

[1]Read before the Radiological Society of North America, at the Eighteenth Annual Meeting, at Atlantic City, Nov. 28–Dec. 1, 1932.

[2]Report on the Use of Radium and Deep Therapy X-ray for the Last Seven Years in a Private Clinic in Maine, with Special Reference to the Problems of the Small Community, Barbara Hunt, RADIOLOGY, November, 1930, XV, 585-589.

a second application of a lesser intensity is made.

This method has been successful in locations all over the face, scalp, neck, dorsum of hand, dorsum of trunk, extensive eroding and bulky growths on rim or shell of ear, tumors containing black pigment or rising from pigmented background, at the inner canthus of the eye and involving the ala of the nose. Needles are sometimes buried in a bulky growth, and, in extensive cancers, treatments are given on successive days until the ground is thoroughly covered. However, such cases constitute a minority of those seen and are becoming fewer in number, due, I believe, to the increased ability of the medical profession to recognize cancer at earlier stages, and to the willingness of the public to accept painless methods of treatment by irradiation.

The three deaths noted were all in ear cases. One had a history of cancer in this location since 1912; one was unfavorable constitutionally, being arteriosclerotic and anemic, and the other had infection and extension into the parotid gland. Infection of the tissues of the head adjacent to the ear is a dangerous complication, and removal of the scab and disinfection of the ulcer with Bohlman's gentian violet solution, together with hot compresses, has, I think, saved one patient.

Recently, recurrence in radiation fibroses in individuals with strong cancerous tendencies (as indicated by multiple skin cancers), has been resected surgically, with immediate rapidly growing recurrence in the edges of the incision. In these cases it is my experience that promptness in the treatment of these recurrences in the edges of the incision is a necessity. In fact, radiation on the day after the operation is likely to catch the activated cells at the most propitious time.

From the standpoint of the patient, I cannot yet see the value of biopsy in cancer of the skin and feel that only rarely is it necessary or justified. Other common diseases do not present the appearance of a translucent, waxy, discrete nodule, or the heaped-up, indurated edge with eroding center, or the dry, slightly scabbing crack with underlying induration. When the cancer is of an infiltrating character, biopsy is dangerous and mutilating; when cancerous tissue is redundant, the diagnosis is obvious. Moreover, it is undesirable to inject a local anesthetic with a view to taking a biopsy specimen and it is not safe to cut into a melanotic tumor. If you must have a biopsy for your diagnosis, wait until after you have treated the lesion with radium since then the biopsy may be harmless. If prominent pathologists find both basal and squamous cells in the same tumor and if squamous-celled tumors sometimes occur in regions popularly allocated to the basal-cell type, common sense and experience teach us to use a sufficient dose in all skin cancers to kill the squamous cells if they are present. As a matter of fact, the decision of the proper dose to use comes within the scope of the art of our profession to a considerable extent and is something that we learn in our apprenticeship. It depends somewhat on the depth of induration, somewhat on the size, and somewhat on the pigmentation, as well as upon the known physical and biologic factors. Another point to be considered is the coloring of the skin of the individual, a very dark skinned person requiring heavier dosage.

CANCER OF THE LIP

This is another field in which radium is highly successful. In 1929 I reported 145 cases of cancer of the lip, with 21 deaths and 99 cases apparently free from the disease. Since then, three have died from recurrences, making 24 known deaths in the years 1922 to 1929. Let us lay aside such deaths as are attributable to other grounds than the method of treatment.

The small uncomplicated cancer of the lip can be treated in a simple way and during a few hours' stay in the office. It is not necessary to put needles through the lip, to curette the growth, to electrocoagulate, to hospitalize the patient, or to do anything more than lay radium over the top of the nodule or on the two sides in order to employ cross-firing. A shield can be made for the rest of the lip out of lead covered with rubber dam attached with patching cement, with a window to uncover the cancerous nodule. A prophylactic treatment over the submaxillary and submental areas consists of erythema bandage packs which may be left on over night while the patient sleeps. Treatment of such cases as are uncomplicated by palpable glands proceeds as uneventfully and surely as that of cases of cancer of the skin. The dosage is a little larger and the excoriation of the lip a little disagreeable, but with the aid of a vaselined cloth between the lips at night to prevent adherence in the morning, the patients are able to continue about their occupations and the lip heals in from six to eight weeks. When there is suspected metastasis in the cervical glands, I employ deep therapy x-ray plus radium packs to skin toleration and find it reasonably successful. Cancers of the lip which have spread beyond the vermillion surface, if not accessible to cross-firing, I treat with buried radiation in addition to external form. I am still using steel-jacketed needles in this work.

In the hopeless cases, with bulky and many metastatic glands and extensive proliferative and eroding sores on the lip, to delay and palliate the growth by burying radium and using deep therapy x-ray is decidedly worthwhile when the final result is compared with the distressing terminations in cases in which the cancer is allowed to proceed uncontrolled. I would urge that we show courage in recommending the use of radiation for its palliative effect upon such cases. The extremely neglected cases are frequently town or state paupers and there is a tendency for the local consultant to consider treatment unnecessary on account of the hopelessness of the case. Let us not lose sight of the fact that radiation furnishes a means of rendering death from cancer less distressing.

Tobacco or foul teeth still play their part and can be depended upon to produce recurrences unless prohibited.

CANCER OF THE UTERINE CERVIX

From 1922 to 1929, 104 cases were treated, the cases appearing free from the disease being 26. During the last three years, five of those 26 cases appearing free from the disease in 1929 have died from cancer. Since then there have been 22 more cases, making 126 in all, and of these there are eight known deaths and seven cases apparently free from disease, making for the ten years 126 cases and 28 apparently free from disease.

In general, these results are far from satisfactory. Many cases improve and the cancer disappears entirely from the vagina and uterus, but four months, six months, a year, or two years later the pelvic floor and rectal wall become infiltrated and death ensues. It seems to me that treatments should be repeated by means of the deep therapy x-ray at intervals during the first year or two. It is too much to expect to cause the death of all the cancer cells at one blow. I find that by using a course of deep therapy x-ray treatments before applying radium, the tumor can be cleaned up and the proliferating growths so shrunken that it is easier to find the uterine canal, and I do not have the rises of temperature, the chills, and signs of toxemia which sometimes follow radium insertion.

My method of treatment uses less filtration than is used in common practice. The steel needles or silver capsules are placed

tandem-fashion in a piece of wax catheter cut to the measure of the uterine canal and covered with thin rubber tubing. This applicator is somewhat flexible, small enough to be inserted without much trauma, and the results seem to justify continuation of its use. The caustic effect is not marked and the local cancer disappears with healing except in the cases of badly infected eroding ulcer. I do not know of any treatment which is more than palliative in this latter condition.

CANCER OF THE BREAST

I have not found deep x-ray therapy successful in causing permanent arrest of cancer of the breast. Of the six potentially operable cases treated by radiation alone which were reported in 1929, two have died from cancer, two more are now undergoing treatment for re-appearance of the disease in the breast, one has just had a radical surgical removal of the breast, and a patient who was treated in 1924 by insertion of radium needles plus fractional deep therapy radiation is the only case left with the disease quiescent. The disease apparently disappeared for long periods of time but recurred in such a state of fibrosis that further treatment only broke down tissue without causing recession of the cancer. However, the immediate effects of radiation of some tumors of the breast are certainly brilliant, and I am sure there is a future for this kind of treatment when we understand better how to apply it.

During the course of radiation on an advanced epithelioma of the breast in which the breast tissue had been reduced to a nodule the size of a thumb and disease was spreading over the skin of the chest as an inflammatory thickening, with a sharply demarcated slowly advancing margin, I was given opportunity of observing the effects of radium on a tissue culture of cancer cells taken from the mammary cancer of a mouse. To my surprise, I found that a comparatively large amount of radiation at short range had no effect upon the cells of the tissue culture for several days; whereas 24 hours after deep therapy radiation of the human breast cancer, there was pronounced shrinking and pallor of the nodule and indurated skin. This would seem to indicate that the action of radiation was not upon cancer cells themselves but upon their bed.

HYPERTHYROIDISM

Out of a total of 34 cases prior to 1929, there have been five operated upon after radium treatment, three who reported themselves unimproved, and 16 with symptoms of rapid pulse, exophthalmos, tremor, and the symptomatic "internal trembling," whose symptoms have been greatly improved and the basal metabolism rate lowered.

Radium is a valuable therapeutic agent in hyperthyroidism. The relief afforded by its application on the glands is remarkable. The heart slows its beat, anxiety diminishes, and tremor is relieved. The tumor usually shrinks and sometimes is greatly reduced in size. Exophthalmos often lessens in degree. Sometimes this effect is produced by a single application of gamma rays on the gland, but more often repeated treatments are necessary. That the therapy is not subjective is shown by the striking decrease in metabolic rate. In the first years of my use of radium, several such cases were restored to health and their daily occupations. A number of cases of lesser degree were benefited. Since the popularizing of the surgical treatment in the hands of specialists, I do not see many cases. If we were to specialize in this line of treatment as do the surgeons, we would be able to hold our patients and produce results which would compare favorably with those of surgery.

CANCER THERAPY IN THE STATE OF MAINE

Radiologists see more patients with cancer and are more interested in solving the problem of cancer than any other group in

the medical profession; in our preoccupation with our new agents of therapy, we are neglecting our responsibility in not taking the lead in the war against cancer. The American College of Surgeons has suggested the formation of special groups in hospitals to study the cancer patients and plan their treatment, but in our State there is only one hospital in which such a group has been formed, the chief reason being that the surgical staffs do not recognize the advantages which would come from an intensified study of each case and the application of modern methods of treatment. Cancer is only one of many fields in which a surgeon is interested, but it is the most important one to a radiologist.

In the State of Maine no radium is owned by any hospital and only one hospital has a deep therapy installation, due to the prevailing idea of the surgeons and roentgenologists that the diagnostic x-ray machine of medium voltage is suitable to treat cancer. The surgeons with whom I am acquainted recognize the post-operative treatment of cancer of the breast, the treatment of recurrences, the treatment of abdominal fibroids, and post-operative malignancies of the ovary by the medium voltage x-ray. Cancer of the cervix when inoperable is referred to the radiologist if there is one available; other inoperable cancers are diagnosed as hopeless and the patient sent home without treatment, without reference to the radiologist, and with no knowledge on the part of the surgeon of what might be done by x-ray or radium.

The cancer committee of the State Medical Society was formerly composed of two pathologists and a radiologist. This committee was interested in cancer, arranged a survey of the State by the American Society for the Control of Cancer, and promoted education of the public. However, it was soon recognized that facilities for treatment were lacking. This year, three surgeons were added to the committee but no progress has been made so far. Radiologists as a class are retiring, modest, and immersed in the problems of their specialty, but I believe they should take the initiative in the organization of the medical profession for the control of cancer.

THE ROENTGEN DIAGNOSIS OF MASSIVE ATELECTASIS OF THE LUNG

By J. B. JOHNSON, M.D., GALVESTON, TEXAS, and
C. F. CRAIN, M.D., CORPUS CHRISTI, TEXAS[1]

MASSIVE atelectasis has been known for a long time, but it is the work of Pasteur, published in 1910, that has been the stimulus and the basis for the more recent investigations in this field. Such able essayists as Bowen, Lee, Tucker and his associates, and Coryllos and Birnbaum have presented experimental evidence which does much to reveal the process of events which leads up to this interesting condition. However, in spite of much recent interest in massive atelectasis, there are, unquestionably, many cases which are incorrectly considered as pneumonia.

The term is applied to a condition of collapse of one or more lobes of the lung. The cause of this collapse is generally accepted to be the complete occlusion of a bronchus, by an aspirated foreign body within a bronchus, or, as is far more common, a mucous plug. The symptomatology will vary within wide limits from the "catastrophe" of Lee

[1]Dr. C. F. Crain was Fellow in Radiology, Sealy-Smith Foundation, at the time the paper was written.

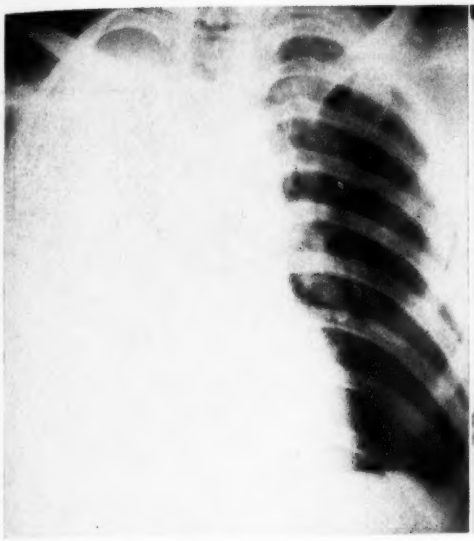

Fig. 1. Massive atelectasis (post-operative). Note marked displacement of heart and mediastinum and contracted thorax on affected side. The right dome of the diaphragm is lost in the generalized density of the right thorax.

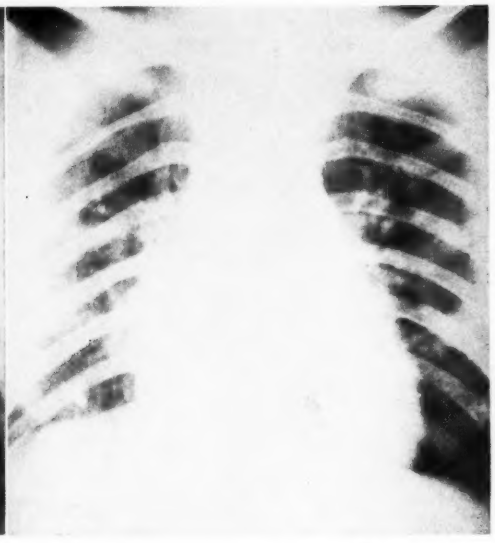

Fig. 2. Same case as shown in Figure 1, two days later.

Fig. 3. Massive atelectasis (medical). The right dome of the diaphragm is held high, the heart and mediastinum are displaced to the right, the thoracic cage on right is contracted, and there is a generalized increased density in the right thorax.

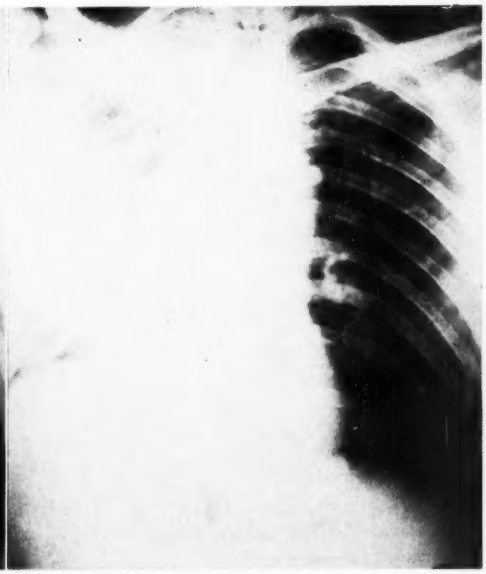

Fig. 4. Same case as shown in Figure 3, two days later. There is partial clearing of the density on the right side, with an abatement of the other signs.

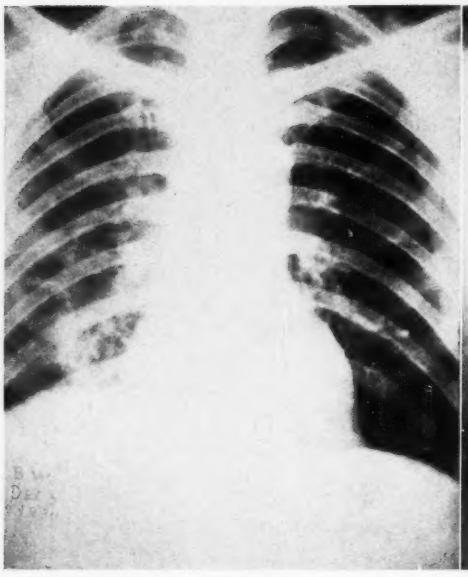

Fig. 5. Same case as shown in Figures 3 and 4, nine days later. The return to normal in "medical" atelectasis is usually much slower than in the post-operative type.

Fig. 6. Lobar pneumonia, two days after onset. The signs of massive atelectasis are present to a lesser degree.

to the case which presents no symptoms whatever.

Physical examination will, in many instances, fail to reveal the true nature of the process, particularly when the atelectasis is complicating or is complicated by another condition. The roentgen examination then appears to be the procedure of choice by which the correct diagnosis may be established, but even the roentgen diagnosis is not always easy and in many cases will be subject to debate and doubt. Therefore, it behooves the roentgenologist to be ever alert for this condition and, as Bowen has repeatedly emphasized, "to think atelectasis."

Fig. 7. Same case as shown in Figure 6, seven days later.

The salient roentgen findings in massive atelectasis are, on the affected side, a contracted thorax with a narrowing of the interspaces, the spine curved from the affected side, the diaphragm held high and fixed, the heart, trachea, and mediastinal structures displaced toward the affected side, and a marked homogeneous density corresponding to the affected part. The opposite side of the chest will show an enlargement of the thoracic cavity with a widening of the interspaces, a depression of the diaphragm, and

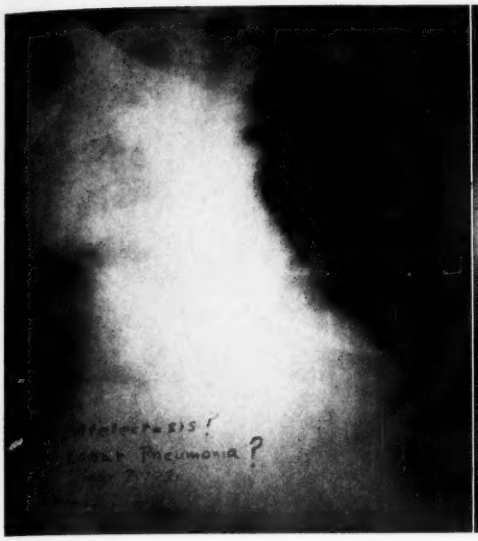

Fig. 8. Massive atelectasis. The upper half of the right lung is involved, with a small area in the medial third of the base, obscuring the right heart border. The thorax is contracted, the diaphragm elevated, and the heart and mediastinum displaced toward the affected side.

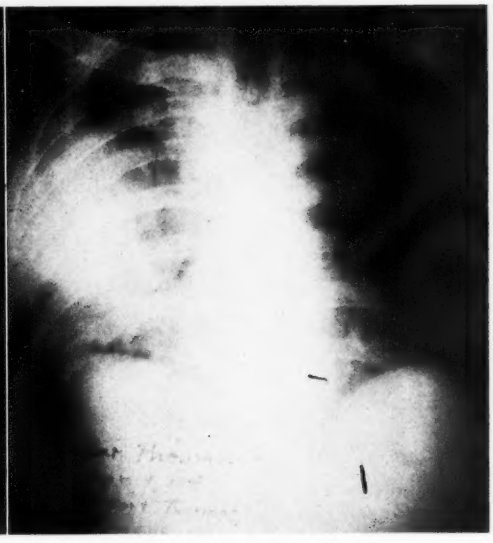

Fig. 9. Same case as shown in Figure 8, only two days later. The areas of pulmonary atelectasis have cleared, the other signs of atelectasis have abated, but there is a lobar consolidation in the middle portion.

an increased radiolucency of the lung. Bowen describes a lateral excursion of the heart with respiration, a pendulum action, whereby with inspiration there is a greater displacement of the heart toward the affected side, while with expiration there is a return to its originally displaced position. He states that in no other condition is there an

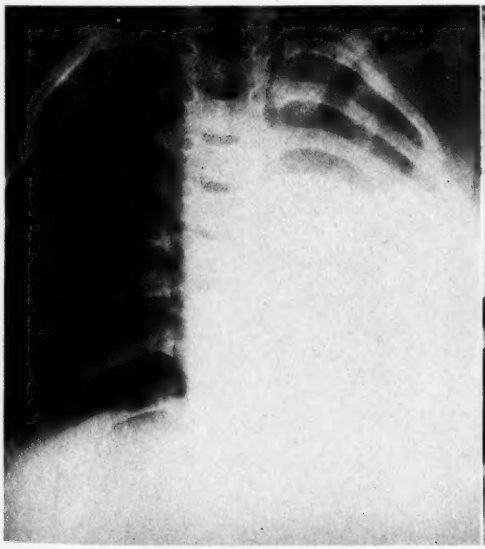

Fig. 10. Massive atelectasis caused by an aspirated foreign body.

Fig. 11. Massive atelectasis from a syphilitic lesion about the hilus.

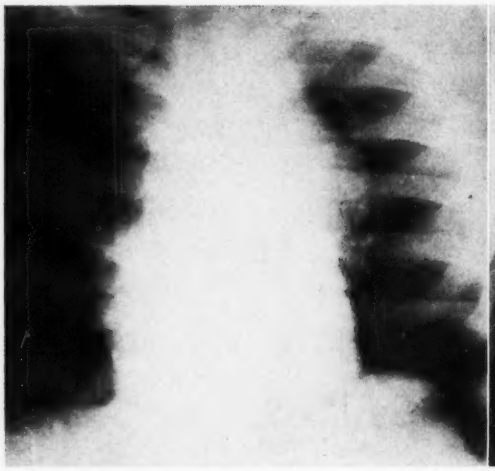

Fig. 12. Same case as shown in Figure 11, 30 days after anti-syphilitic treatment was instituted.

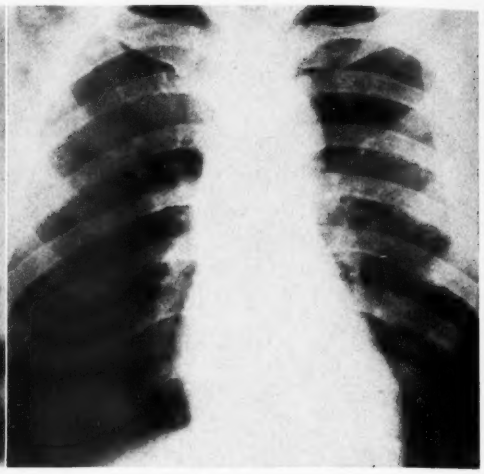

Fig. 13. Metastatic sarcoma in base or right lung.

appreciable lateral excursion of the heart with respiration.

A typical and uncomplicated case of atelectasis will cause such a striking picture that there is little likelihood of error. However, the more frequent case will probably not present all these characteristic findings to a marked degree. Any of these signs may be present to a greater or lesser extent in other conditions and may be all combined to a lesser extent in an apparently true pneumonia. Errors in interpretation will, therefore, be occasioned by any condition which presents all these signs, perhaps in minor degrees, or a few of these signs in a marked degree.

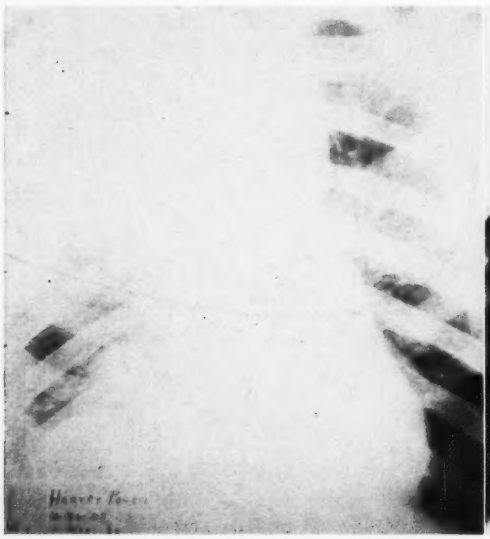

Fig. 14. Same case as shown in Figure 13, showing evolution of deposit and development of atelectasis in upper lobe.

Fig. 15. Massive atelectasis from primary carcinoma of bronchus.

Fig. 16. Later film of same case as shown in Figure 15, showing complete atelectasis on right side.

Fig. 17. Autopsy specimen of same case as shown in Figures 15 and 16, showing the primary carcinomatous growth in the bronchus.

Bowen says that atelectasis must be differentiated from lobar pneumonia, bronchopneumonia, infarct, pneumothorax, subdiaphragmatic abscess, embolism, pleural effusion, and fibroid tuberculosis. Without doubt pneumonia will be the far greater source of error. Coryllos and Birnbaum have compared atelectasis and pneumonia and have reminded us of the similarity of the two conditions, both clinically and roentgenologically. Their views, though extreme, are interesting. They conclude in their studies that etiologically atelectasis and pneumonia have a common basis, *i.e.*, the complete occlusion of a bronchus, the difference being only in the type of the invading organism, which will modify according to the type of organism, the sequence of events following. It is not within the realm of this paper to discuss these points, but one cannot deny that there is a similarity if not a relationship between these two conditions. Bowen has estimated that probably 70 per cent of the cases of so-called post-operative pneumonia are in reality cases of atelectasis.

Aside from an area of increased density in pneumonia, the elevation of the diaphragm on the affected side appears to be the most frequent sign common with atelectasis. It is infrequent to find a displacement of the heart, trachea, or mediastinal structures to the extent usually found in atelectasis, but a minor degree of displacement of these structures appears to be quite common. With such striking similarity between the two conditions, it becomes increasingly apparent that the roentgenologist should be on his guard relative to lobar consolidations. A distinction between the two is prognostically and therapeutically of great importance, but it appears that there are cases which from the roentgenological standpoint are borderline.

Massive atelectasis is not likely to be confused with the other conditions which may give rise to one or all of the roentgen signs of it. The diaphragm is seldom found as high as in massive atelectasis, save in subdiaphragmatic abscess or fibroid tuberculosis, differential diagnosis of either of which should not cause difficulty. A slight displacement of the heart and mediastinum is frequently found, but other changes, or lack of changes, accompanying it will usually

suffice to differentiate between the existing condition and massive atelectasis.

A typical case of post-operative massive atelectasis is seen in Figure 1. This illustrates all the cardinal points of the roentgenographic diagnosis. Figure 2 shows the same case two days later.

Figure 3 illustrates the chest which clinically and roentgenologically was considered massive atelectasis. This case was not post-operative, but followed an acute bronchitis. Figures 4 and 5 show the same case two and nine days later, respectively. The similarity of this case to a frank pneumonia is evident on comparing it with Figures 6 and 7. Figure 6 is the roentgenograph of the chest of a pneumonia patient two days after the onset. All the signs of an atelectasis are present but to a minor extent. Figure 7 is the same case seven days later.

Figures 8 and 9 are of the same patient two days apart. Clinically the patient had a pneumonia, though the roentgenographic opinion on the first film was massive atelectasis. This condition of the upper lobe cleared in two days' time, as an atelectasis might be expected to do, but coincident with this clearing there developed a consolidation of the middle lobe on the right side, which roentgenographically ran the course of a pneumonia.

Figure 10 is that of an atelectasis produced by the aspiration of a foreign body, a black-eyed pea, which blocked, completely, the left main stem bronchus. No film is available after the bronchoscopic removal.

Figure 11 shows an atelectasis in a case that clinically presented no clue as to the etiology except a positive Wassermann reaction of the blood. Anti-syphilitic treatment was instituted and Figure 12 shows the case thirty days later.

Figure 13 shows a metastatic sarcomatous deposit in the base of the right lung. The evolution of this deposit is seen in Figure 14, together with an atelectasis of the upper lobe of the right lung, due, undoubtedly, to an occlusion of the upper lobe bronchus by a similar deposit.

Figure 15 shows an atelectasis of the upper portion of the right lung which developed in the course of two months to a complete massive atelectasis of the right lung. The etiology was obscure until, at autopsy, a primary carcinoma of the bronchus was revealed.

SUMMARY

1. The salient features in the roentgenray study in massive atelectasis are mentioned.

2. The similarity of acute lobar pneumonia to massive atelectasis from the roentgenologic viewpoint is discussed.

3. Films are presented representing different types of atelectasis.

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CASE REPORTS

PRESENTATION OF A CASE OF TUBERCULO-SILICOSIS

ITS ROENTGEN, PATHOLOGIC, AND MINERALOGIC FINDINGS

By PHILIP H. PIERSON, M.D., San Francisco

TUBERCULO-SILICOSIS is not an unusual condition by any means, but this case presents certain interesting features which warrant its being reported.

(1) The man, aged 46 at the time of his death, April 13, 1932, had worked steadily as a dry driller in quartz dust from 1914 to 1917 and then about one-third of the time during the next seven years. When first seen in 1924, there was evidence of a tuberculous infection in the right apex and hilar glands but no signs of pneumonoconiosis.

(2) Serial roentgenograms were taken in 1924, 1925, 1928, 1930, 1931, and 1932, and, beginning with 1925, the gradual development of an extensive nodular infiltration was observed. There was evident difficulty in differentiating whether this was due to a disseminating tuberculosis or to silicosis.

(3) Postmortem examination was performed and the nodules studied both for the cellular reaction and for the presence of silica. The latter, if found, is of value in establishing the diagnosis of silicosis. Its presence indicates that the development of silicosis is not dependent upon a prolonged or constant exposure; also, that even after exposure ceases the latent irritation may go on and produce the final stages of disease.

It is often difficult to distinguish microscopically a tubercle due to silica alone from an early tuberculous tubercle. The experimental work of Gardner (1) (2), working with non-immune and infected animals, has shown that the following criteria are helpful:

"(1). Sections should be stained for tubercle bacilli—sometimes they may be present but difficult to find. If found, it is evident that infection has taken place, but if not found, the reverse is not so. Animal inoculation is a surer diagnostic criterion.

"(2) True caseation is present more often in the presence of infection, while a hyaline degeneration and fibrosis are often the result of pure silicosis. Here, again, degenerative changes with epithelioid and giant cells may be found in silicosis alone.

"(3) The stages in the development of both are quite similar. Pure silicotic tubercles are composed, first, of clusters of epithelioid cells. As these mature an increasingly heavy reticulum forms, and the cells become compressed and spindle-shaped so that the nodules resemble sarcomatous tissue. Slowly, degenerative changes make their appearance at the center. The fibers swell and stain deeply with eosin; later they become hyaline and most of the nuclei fail to stain. The peripheral zone of lymphocytes, so common in tuberculosis, is not so well developed in silicosis. The margin of the nodule in the latter disease is generally more clearly defined and often demarcated by a definite layer of metaplastic cuboidal epithelium. These are general features which may or may not be present in any given nodule. However, they in general characterize the reaction which occurs apart from infection. In cases in which tuberculosis is superimposed, there is a greater tendency for degeneration to occur and it is often granular rather than hyaline in its appearance."

It is known that dust particles are aspirated into the ductus alveolares and localize, particularly in those lymphatics about rigid structures, such as blood vessels and bronchi, where there is less motion than in the more flexible portions of the lung. Tubercle bacilli originally localize in a similar way. The presence of either of these foreign bodies sets up a reaction which eventually becomes fibrotic, perhaps caseous, and even calcified. This fibrosis will frequently delay or retard a process which might otherwise be more rapid, but its disadvantage is

that an increasing wall of fibrosis excludes the phagocytes which carry off infection and débris. If the inhalation of dust is not too massive or continuous and if the individual's reaction to his tuberculosis is favorable, the development of the fibrosis may be so slow that it takes years to be evident, clinically or roentgenologically, and thereafter its further development may be slow. When the blocking of the lymphatics or tracheobronchial glands eventually becomes complete, the peripheral lesions are likely to develop more rapidly and death takes place. From this it can be seen that, in general, the

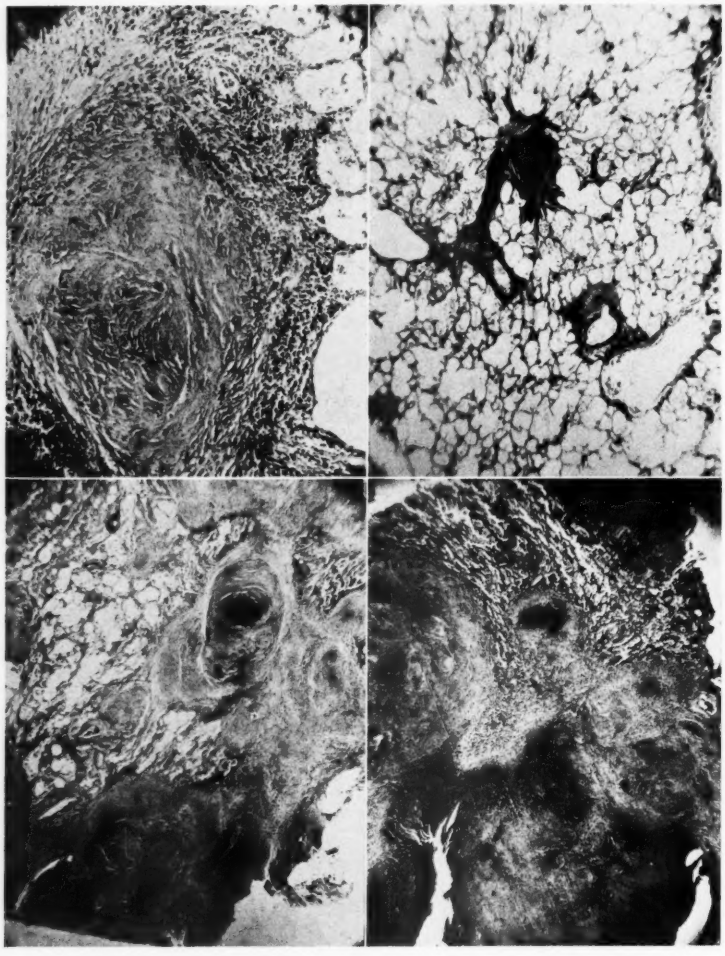

Fig. 1 *(upper left).* Pure silicosis (?) from left upper lobe. Central zone is hyaline rather than necrotic. It is rather sharply demarcated with the peripheral zone composed of small round cells and fibroblasts (× 200).

Fig. 2 *(upper right).* Early localization of foreign material about blood vessels and bronchi; left upper lobe. This accounts for the linear type of scarring seen before nodular areas appear in the roentgenogram (× 50).

Fig. 3 *(lower left).* Infection and silicosis; right lower lobe. Caseation still very slight, fibrosis is marked (× 50).

Fig. 4 *(lower right).* Caseation predominates over silicosis; right lower lobe. Very light repair evident. This is the only section in which tubercle bacilli were found in tissue (× 50).

outcome is the same, whether tuberculosis antedates or follows the aspiration of silica.

Many different forms of dust are inhaled and the same reaction is not present in all of them. For instance, coal dust (?) is far less damaging to the lung than free silica. The size, shape, and sharpness of the spicules play important rôles in their reaction. The coal is probably more irritating and is consequently "washed" out of the lungs, whereas the silica, with less immediate irritation, remains and sets up the reaction mentioned above. Hefferman (3), in his study of stonemasons, states that a nodular pneumonoconiosis does not occur in calcareous workers—those exposed to marble, calc spars, various limestones, Portland stone, Bath stone, Caen stone, Hopton stone, Auston stone, and so forth. Free silica is found in quartz, quartzites, granite, flint, chert, millstone grit, and sandstones in general. Combined silica is present in traps, schists, slates, serpentines, chrysolites, hornblendes, felspar, basalts, as well as in all clays. Glass is composed of combined silica. It is quite evident, then, that a worker in silica of any of the above-mentioned forms, harboring particles of this substance in his lungs, may not manifest its presence clinically or roentgenologically while engaged in this occupation, and several years may pass after his leaving this work before the nodular reaction manifests itself.

Fig. 5. Cross-section of lungs showing lesions of tuberculo-silicosis.

CASE REPORT

D. P., aged 46, married, was first seen at the Stanford Chest Clinic April 17, 1924. By occupation he was a dry driller in a quartz mine, where he had worked for three years steadily (from 1914 to 1917) and for about a third of the time during the next seven years. In the latter part of 1924, after being first seen in the clinic, he worked one month at the same type of drilling but never thereafter.

Present Illness.—He had been in good health, active and strong, until six weeks previous to the initial examination, when he contracted an acute respiratory infection—a "cold"—and three weeks later expectorated 2 c.c. of blood on four or five occasions. His cough was dry, he tired easily, had a few night sweats, and was somewhat short of breath. His appetite and digestion were good and his elimination normal. He had no pains in his chest. His best weight, four years previously, was 160 pounds, his average weight was 155, and his present weight 146 pounds.

The patient's past history was negative and

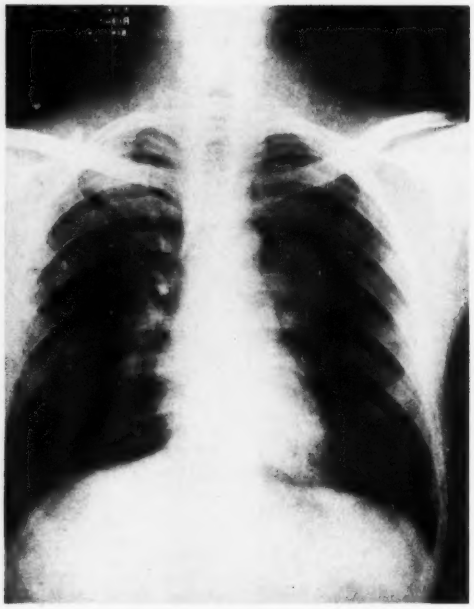

Fig. 6. Film made in April, 1924.

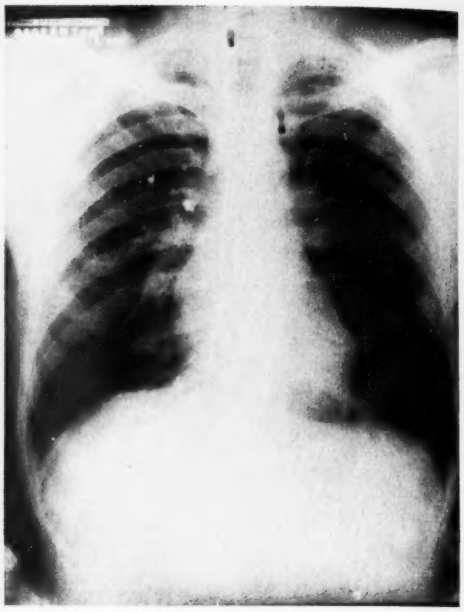

Fig. 7. Film made in 1925.

his family history showed no exposure to tuberculosis.

Physical Examination.—Well developed and nourished. Teeth, tonsils, glands, and heart within normal limits. The lungs showed some wasting in the left apex and a slight lag on breathing. Breath sounds were bronchial in character at the right apex but no râles were heard, even with cough. Abdomen and extremities normal.

Laboratory Tests.—Blood Wassermann was negative. Blood count: Hemoglobin, 72 per cent; white blood cells, 8,000 (differential count: polymorphonuclear cells, 72 per cent; lymphocytes, 27 per cent; transitionals, 1 per cent). Urine was normal except for a slight trace of albumin. Sputum showed no tubercle bacilli.

X-ray examination (April 19, 1924).—"The rib case is fairly symmetrical, with a slight compression of the left top, apparently due to a slight scoliosis in the upper thoracic spine. There are well-marked pleural scars across both apices and within the right apex there is an area of pneumonic density, with increased density in the bronchial tree branches, and with altogether the characteristic x-ray appearance of tuberculosis. Both lung roots are abnormally heavy and the right hilus includes a large calcification. There is thickening of the pleura between the lobes of the right lung. The heart vessel shadow is not remarkable.

"Conclusions: Tuberculosis, very marked, in the right upper, and probably present also in the left apex and both lung roots."

Progress Notes.—After hospitalization for two months the patient's weight increased to 152 pounds. In October, 1925, he was doing a full day's work as a farm laborer and his weight was 147. He complained of some cough and dyspnea; his physical signs were as before.

X-ray examination (Oct. 5, 1925).—There is a slight but definite irregular clouding throughout both lung fields, a generalized involvement which was not noted a year and a half ago. On review of the old films, however, it is seen that there was at that time a faint suggestion of the same clouding, at least in the right lower lobe. Evidence of consolidation at the right apex persists and the left apex is still only gray.

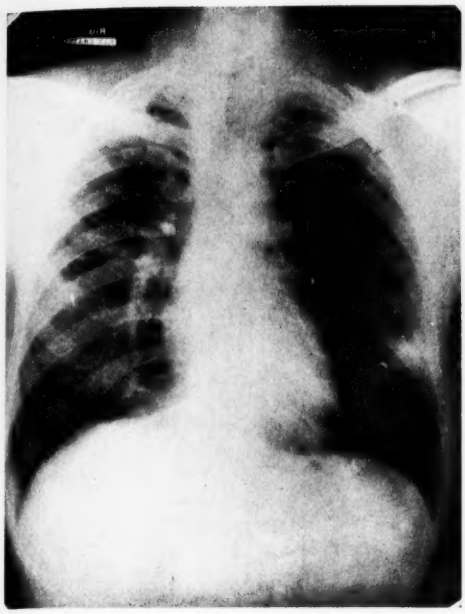

Fig. 8. Film made in 1928.

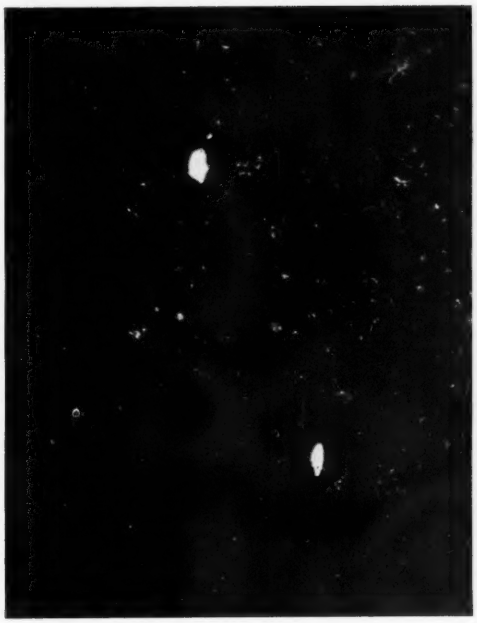

Fig. 9. Silica crystals recovered from lung. Photograph made in June, 1932, showing fragments, with ash particles, of which there were two quarts (× 120).

Conclusions: It seems likely that tuberculosis has become more widely disseminated throughout the lungs.

Progress Notes.—In July, 1928, he reported as feeling well and weighed 151 pounds. Physical examination then showed some dullness over both apices, with harsh breath sounds over the right apex but no râles were heard.

X-ray examination (July, 1928). — The cloudiness and mottled density previously noted are more widespread through the lungs than they were at either of the previous examinations, so that at the present time there is scarcely any portion of the lung field on either side which appears normal.

Conclusions: The cloudiness and mottling in the lung fields might be attributed to pneumonoconiosis but when studies of the development of the case since April, 1924, are made, it seems much more likely that the diagnosis of disseminated tuberculosis is the correct one.

Progress Notes.—At this time the intracutaneous tuberculin test with 1/10 mg. O.T. was negative.

In April, 1929, his weight was 153 pounds, he was feeling well, and had less cough than usual. Physical examination of his lungs showed a lag of the left chest and some muscle spasm on the same side. Breath sounds were harsh over both apices. A few scattered râles were heard over both bases only. His sputum showed no tubercle bacilli.

He was seen on February 18, 1930, and did not feel so well. He tired easily and felt feverish in the afternoon. He had some cough but almost no expectoration. He had been working on a ranch. His weight was 153 pounds. His lungs showed the same physical signs as before. Intracutaneously 1/10 mg. O.T. produced only a mildly positive reaction. A chart showed that his temperature had been 100° F. on two or three days and his sputum showed tubercle bacilli for the first time.

X-ray examination (Feb. 18, 1930).—Since the last examination there has not been a great deal of change in the appearance of the chest, except that the disseminated areas appear to stand out a little bit more distinctly. Most of the involvement is in the right upper and mid-

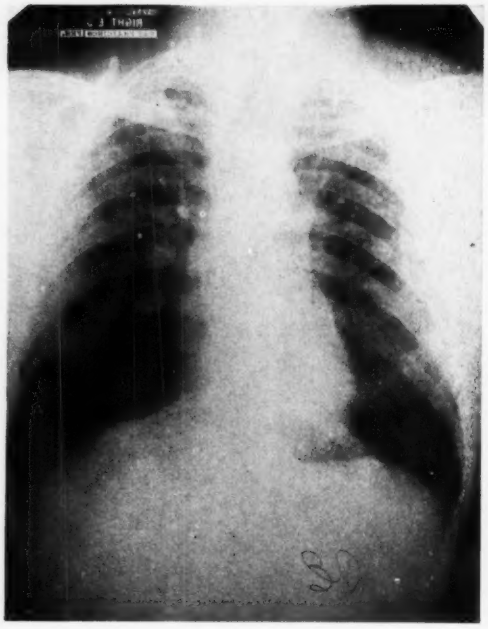

Fig. 10. Film made in 1930.

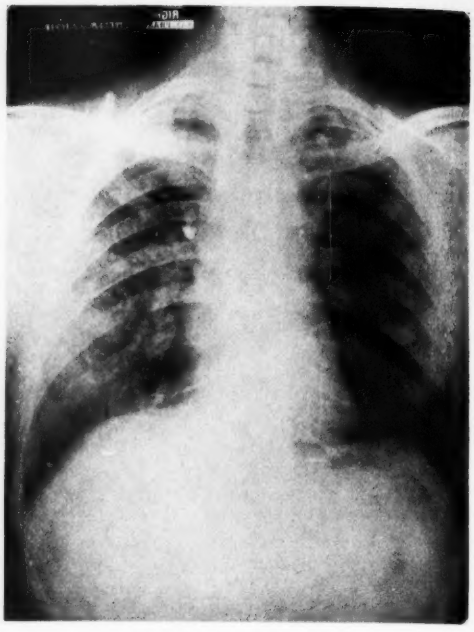

Fig. 11. Film made in 1931.

dle lobes, and in the left upper lobe, leaving the lower lobes relatively clear, but probably not absolutely free. No tubercle-like areas are seen in the region of the spleen, therefore, this has been a tuberculosis disseminated through the lymphatics, rather than a miliary tuberculosis, spread through the blood stream.

Conclusion: Disseminated tuberculosis, which has not advanced in the past year and a half.

Progress Notes.—He then spent fourteen months at the Hillcrest Sanatorium, where another sputum examination was positive. While there, he had a small hemorrhage. The medical examiner of the sanatorium stated that the physical examination showed "very indefinite signs in his lungs, impaired resonance on the right to the second rib, impaired breath sounds with indefinite signs of cavity at the second dorsal spine on the right, but no râles were heard."

The patient reported again on May 19, 1931, saying that he had a slight cough and expectoration, no night sweats, fever, or fatigue, but some indefinite pains in his chest. Physical examination showed restricted motion in both lungs, some dullness over both upper lobes, and a few fine râles over the upper lobes on both sides, the right more than the left. His temperature record showed no fever and his blood sedimentation curve was that of a quiescent case. His sputum was negative for tubercle bacilli. On Sept. 22 and again on Oct. 22, 1931, he reported as having pains on both sides of the chest with deep breathing. A dry cough was present and he was more easily fatigued. His weight had fallen to 144 pounds. Physical examination showed some dullness at both apices, with a few fine crepitant râles over the left apex posteriorly. There were distant breath sounds and a few pleural crepitations in his left axilla and a pleural rub near his right hilus posteriorly. His sputum was positive for tubercle bacilli.

X-ray examination (September, 1931).—Since the last examination there has been increase in distribution and size of the disseminated areas of density, so that practically the entire lung field now presents a snowflake appearance. The calcification at the upper right lung root has not changed. Behind the left fourth rib there is a small area of decreased

density which suggests cavitation. No other cavities are noted.

Conclusions: In spite of the history of old tuberculous infection in the apices, and in spite of the rather rapid development of the disseminated densities, the character of the lesions as shown by the x-ray examination suggests that the patient's condition is largely due to pneumonoconiosis and not to disseminated tuberculosis. Of course, there is undoubtedly some tuberculosis present as well, and the suggestive cavitation on the left side is probably tuberculous.

Progress Notes.—In February, 1932, he went to a county sanatorium, where his temperature ranged from 99 to 100°. He steadily became worse and died April 13, 1932.

Autopsy.—Sections were taken from several parts of the lungs and the pathology showed all stages, from what appeared to be pure silicosis to areas where tuberculosis dominated the lesion. The accompanying illustrations show characteristic sections. Sections were removed from each apex and base and were analyzed by a mineralogist for the presence of silica. The following is his report.

Determination of Silica in Lung Tissue.—The samples to be analyzed, which were suspended in salt solution, were squeezed as dry as possible between paper towels, cut into small pieces, and dried to constant weight (about 6 hours) at 70° C. They were burned and ignited in a 100 c.c. platinum dish over a Méker burner, and the ash weighed. Since sulphuric acid was necessary in the subsequent treatment with hydrofluoric acid, the ash was treated with sulphuric acid and again ignited, the resulting weight (which differed only slightly from that of the untreated ash) being used in calculating silica content. The ash was then treated with hydrofluoric and sulphuric acids and ignited, the loss being taken as SiO_2.

ANALYSIS

	Left Base	Right Base	Left Apex		Right Apex
Dry sample (grams)	0.908	1.322	2.160	0.883	1.130
Ash (grams)	0.0456	0.0637	0.0801	0.0341	0.0542
SiO_2 (grams)	0.0178	0.0267	0.0286	0.0124	0.0215
Ash in sample %	5.03	4.82	3.70	4.10	4.80
SiO_2 in sample %	1.96	2.02	1.32	1.49	1.90
SiO_2 in sample %	39.0	41.9	35.7	36.4	39.6

CONCLUSIONS

1. Silicosis in this case did not make its appearance roentgenologically or clinically until after a period of five or six years of mining, a total time of ten years from the beginning of the patient's exposure to silica dust.

2. Its progress is noted in serial roentgenograms taken over a period of seven years.

3. Pathologic study shows that most of the lesions were due to combined silicosis and tuberculosis and their general reaction in the lung was very similar.

4. The spread of tuberculosis took place only when the fibrosis due to the two conditions had interfered with the normal phagocytic reaction.

5. The fact that silica was basically responsible for this appearance is shown by the fact that approximately the same percentage of silica is present in all parts of the lung.

6. This case presents an industrial problem. In cases in which silica has been inhaled the roentgenogram may not show the reaction to it for some time, and, hence, liability may be determined only after a waiting period has passed.

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BASAL-CELL EPITHELIOMA: TWO CASE REPORTS

By JOHN S. DERR, M.D., FREDERICK, MARYLAND

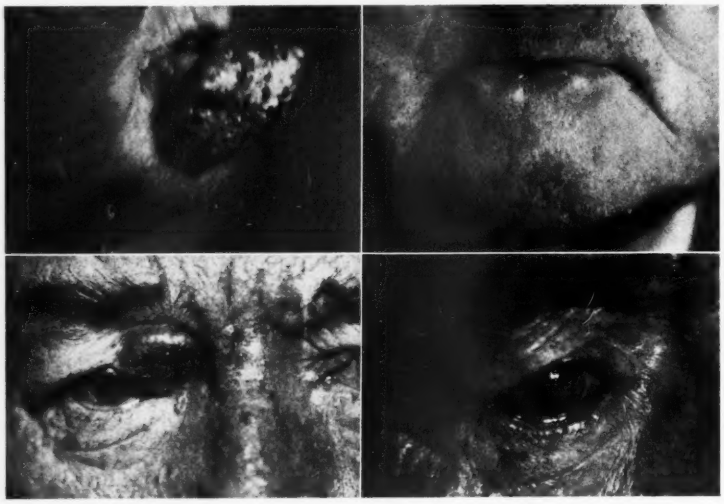
Case 1. This is a case of basal-cell epithelioma of the lip, treated with combined electrocoagulation and x-rays. The patient was a white male, aged 66, who came for treatment June 27, 1931.

History.—About a year previous to examination, while the man was being shaved, the barber, with his finger nail, cut the patient's lower lip. The abrasion did not heal promptly, and was treated with ointment. A growth then began in the wound which gradually increased in size until it covered practically the whole lower lip and hung over to the crease of the chin; upon examination, it measured $5 \times 3 \times 1.05$ square centimeters.

Examination.—The mass showed ulceration of the surface of the mucous membrane, extending down inside the lip, although the mass of the growth, which hung far below its attachment, was not ulcerated.

Diagnosis.—It had all the appearance of a basal-cell epithelioma, and, since a microscopic examination would not alter the indications for treatment, none was made. There were no palpable glands in the submaxillary or submental regions. Before treatment was begun, photographs were made of the growth (Fig. 1).

Treatment.—After anesthetization by a hypodermic injection of 1 per cent butyn a considerable portion of the growth was destroyed by electrocoagulation at the first sitting. This was followed by cross-firing with x-rays, the technic being a 9-inch spark gap, 4 ma., 0.5 mm. Al filter, 9-inch distance. The mouth was protected with lead foil in the inside of the lip. The total time of this first treatment was 20 minutes.



Figs. 1 and 2 *(above).* Basal-cell epithelioma of the lip showing lesion and end-result after treatment. (Case 1.)
Figs. 3 and 4 *(below).* Basal-cell epithelioma of the eyelid, showing end-result. (Case 2.)

A second x-ray treatment was given on the lip, while the glands of the neck were four times cross-fired in three directions, using a filter of 6 mm. of Al. The estimated dosage to the lip was five erythema doses.

Result.—After a moderately severe local reaction, the healing was progressive and continuous. Four months after the first examination a second photograph (Fig. 2) was taken, showing a complete reduction of the growth. At present, the mucous membrane of the lip

is soft and there remains only a small scar. The glands show no enlargement and after a year and a half the patient seems in good health.

Case 2. This is a case of basal-cell epithelioma of the eyelid in a man 81 years of age.

History.—The lesion on the left eyelid made its appearance about three months before the date of my examination on Dec. 6, 1932. It seemed to be a small pimple and was treated by the man's family physician with ointments.

Upon examination it was seen to have grown to an elevated mass measuring 2×2 cm. in diameter, with a necrotic center and overhanging edges. A diagnosis was made of basal-cell epithelioma. Before beginning treatment a photograph (Fig. 3) was taken of the growth.

Treatment.—Under local anesthesia by butyn, fulguration was done of the necrotic center and under the edges, down to the meibomian cartilage. This was followed by what amounted to about three erythema doses of x-rays (9-inch spark gap, 4 ma., 0.5 mm. of Al, 10-inch distance, 15 min.), during which the eye was carefully protected with heavy lead foil. X-ray treatment was repeated on Dec. 13 and again on Dec. 27, a total of seven erythema doses being given. Following each treatment the area was touched with mercurochrome.

When the patient was last seen (Fig. 4), four months after the initial treatment, the area appeared to be completely healed, the skin was normal, and there remained only some conjunctivitis.

ANNOUNCEMENT

The papers read before the Congress have been divided on an equitable basis between the publications of the American Roentgen Ray Society and the Radium Society and the Radiological Society of North America, and RADIOLOGY expects to publish a considerable number of them during the coming year.

EDITORIAL

PROBLEMS IN CERTIFICATION OF RADIOLOGISTS[1]

The *Bulletin of the American Medical Association* recently reported that approximately 40 per cent of recent graduates limit their practice to a specialty and another 40 per cent are giving particular attention to a specialty. Undoubtedly a great many of these physicians do not have the desired qualifications. This is true in the specialty of radiology as it is in most other specialties.

According to the directory, 1,783 physicians limit their practice or give special attention to radium therapy and roentgenology. This group occupies the eighth place in numbers of physicians in the twenty-five specialties listed. The youngest specialty already embraces 3.7 per cent of all physicians designating themselves as specialists.

The tendency of recent graduates to elect specialties rather than general practice is important in our consideration. Medical students to-day are evidently imbued with the idea that the science of medicine is so extensive that no one person can hope to compass the whole subject, and, therefore, each one should try to limit himself to some particular branch.

Often a recent graduate, with no broad preliminary training or with only a few weeks' training in a post-graduate course, holds himself out as a radiologist or roentgenologist; thus the pseudo-specialist in roentgenology appears. Dr. J. B. Herrick states in an article appearing in *The Journal* that, "when the profession fails to keep the ideal of benefit to the patient before it, practice will degenerate and will be in essence dishonest." It may possibly be construed as dishonest to hold oneself out as having superior knowledge and training in a certain branch (which is often the impression received by the public) when training has not actually been consummated. That danger attaches to the physician who is specialist in name only, who is poorly prepared, and lacks proper graduate study and broad experience.

Objections to too much specialization are evidenced in the literature of the past few years and should constitute an argument in favor of certification of those specialists who have the proper qualifications. Objections in the main are not against the institution of specialization, for this progress is inevitable, but are directed against the self-appointed or pseudo-specialist, who has had only a minimum, or no, post-graduate experience.

The field of radiology seems to be especially attractive to the recent graduate, as well as to the ambitious lay person, for the reason that mechanical devices are employed. To the uninformed public it appears that little training or special knowledge is necessary. You know, possibly better than I do, the number of lay persons trained as technicians who have established radiologic laboratories and who often attempt to give the impression that they are medically competent. The group attempts to convert this special branch of medicine into a trade and to carry an impression to

[1]Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30–Dec. 4, 1931.

the public that medical training is not essential. In many instances, physicians themselves patronize lay laboratories, thus fostering them. Often lay-controlled laboratories hire physicians to sign their reports while the actual work, even the interpretations, is done by lay persons. This constitutes somewhat of a problem in certification.

Since most of the branches of medicine look to the specialty of radiology for important aid in diagnosis and treatment, the careful certification of qualified physicians should be made to protect the patient and the profession. A powerful influence in the regulation of those qualified is, of course, a membership in special radiologic societies. The societies immediately bar the lay practitioner and, to a certain extent, the physician who has not had adequate training and experience; they do, however, admit men whose major work is in other specialties. This is notably true of some surgeons who also use radiology. It is obviously difficult to know where to draw the line, since it is certainly admitted that a physician may be proficient in more than one specialty.

The American Medical Association has assisted in placing the specialty of radiology on a par with the other specialties through its hospital work. Requirements regarding radiologic service are included in essentials for registered hospitals, hospitals approved for internships, and hospitals approved for residencies in specialties.

In 1928 the House of Delegates of the American Medical Association received requests from sections on radiology of several medical societies for supervision of laboratories of roentgenology and radiology similar to that already established over clinical laboratories. The request was granted and a committee of radiologists outlined the plan of procedure. Essentials were established and an adequate questionnaire was formulated and distributed. After carefully checking each candidate in the biographic files and receiving sufficient recommendation from advisers (who are outstanding radiologists in various sections), a tentative list of physicians conducting approved laboratories or departments of radiology or roentgenology was published on May 23, 1931. The Council will maintain this list as an active part of the work. Additions and revisions will be made from time to time; suggestions for changes and consideration of new applications will go on continuously. Co-operation by the men in the specialty has been excellent and must continue in order that the work may be of optimum value.

The committee of radiologists logically places stress upon the personnel of an approved department of radiology or roentgenology. The director and other physicians in the department are considered consultants by the profession, and, as consultants, they are practising medicine and should be licensed in the State in which they do their work.

The Council has understood from the very beginning, and has advocated the principle, that the practice of radiology and roentgenology is the practice of medicine. It has followed this principle in the interpretation of the essentials, in the preparation of its lists, and in every opportunity that it has had to express itself on this point to the entire medical profession.

The Council requires that roentgen-ray facilities and records shall be adequate. Publications containing the requirements, as well as several other pamphlets on radiologic service in hospitals, have repeatedly been sent to every hospital in the United States and have been in use for many years. The essentials of a hospital approved for residencies in specialties, having the same requirements except in cases in which the special training is in the field of roentgenology, have been sent to several hundred hospitals that have applied for approval for residencies in specialties.

The essentials of a hospital approved for

interns are that the department be equipped for at least roentgenographic and roentgenoscopic procedures and be directed by a physician-roentgenologist who is properly qualified for the work which the department purports to do. Records must be on file in the department, and copies should be filed with the clinical charts. The Council has never endorsed a hospital or other medical institution in any way when it was known that lay specialists were employed for roentgen-ray interpretation or therapy.

While no revolutionary changes could be expected in so short a time, we can be sure that much has been done by way of education through constant publication of requirements, their enforcement, so far as reasonably possible, and through first-hand inspection of over a thousand hospitals and laboratories.

Doubtless the chief reason radiologists requested an investigation and the publication of a list of those found competent was the tendency of unqualified individuals, both medical and lay, to hold themselves out as specialists in radiology. Many problems are involved in making up such a list, a few of which I shall mention.

1. Should the list be comprehensive and embrace all men trained in roentgenology whether or not they are available to the general profession for consultation?

If it is to be a complete list, physicians in the Army, Navy, Veterans' Administration, United States Public Health Service, medical colleges, and various governmental laboratories should be included. These physicians are specialists to the same degree as those who are offering their services to the general profession in commercial laboratories or hospitals.

2. If the list is to include all who qualify, regardless of position, should it be constructed in such a way as to designate those who offer their services to the profession and those who are in administrative capacities or in governmental service?

3. Should the list of radiologists and roentgenologists include the names of men who designate other specialties for themselves in the American Medical Directory?

The American Medical Association has not yet set the precedent of allowing a physician to designate himself in the directory under more than one specialty. It would seem to be inconsistent for a physician's name to appear on a list of radiologists and at the same time to be under some other specialty. There are a number of applications from physicians who have designated their specialties as other than radiology, such as surgery, internal medicine, or clinical pathology. They may devote from one to four hours a day to radiologic work and qualify in training and experience, but a substantial amount of their time is devoted to, and their main interest lies in, another specialty. While these men are worthy of favorable consideration, in order to be consistent it may be necessary that their designation in the directory be changed to radiology.

4. Should physicians employed by lay organizations be considered?

The main objection in the consideration of such candidates is that too often lay-controlled laboratories use unfair methods of advertising and price-cutting.

Without doubt the Council's work will have, and has had, a good effect on this situation, but the work of establishing reliable lists and of checking the laymen and other incompetents has only begun.

The Council appreciates the splendid cooperation of the men in roentgenology and radiology who have made this survey possible. It is especially grateful to those men who serve as the advisory committee in the various sections. These men have cheerfully lent their efforts and time to the Council to obtain first-hand information concerning applicants for listing.

O. N. Andersen, M.D.

PAST-PRESIDENT BYRON H. JACKSON, M.D.

The term of office which ended with the Congress of Radiology in September has revealed the able leadership of Byron H. Jackson, M.D., of Scranton, Pennsylvania. Intimately acquainted as he is with the executive acts and scientific progress of all the radiological societies, Dr. Jackson's official acts and personal influence have contributed to the development of new apparatus, to clearing up what has come to be called "the tube situation," to promoting a spirit of fellowship among radiologists, and to the extension of education in radiology in medical colleges.

In addition to a genius for friendship, Dr. Jackson has in a high degree the power of inspiring confidence in his associates. To the honorary posts already filled by him, he has now added that of Past-President of the Radiological Society of North America. Also, he has been chosen as a six-year member of the Qualifying Board, upon which he represents the American College of Radiology. This Board will act in an advisory capacity to standardize the education of those who would specialize in the practice of radiology.

RECOLLECTIONS OF THE AMERICAN CONGRESS OF RADIOLOGY

The first American Congress of Radiology—what is the verdict? Was its object achieved? Did it come up to the expectation of its creators and of its members? Has it paved the way for a unified group meeting of all the interested bodies in the near future?

To the writer, these questions can all be answered in the affirmative.

The Congress will likely mark an epoch in the development of radiology on this continent. No yearly meeting has ever assembled such exhibits either of clinical material or apparatus; indeed, a five-year advance would seem to have been made. It is said to have been the largest of its kind and to represent adequately the rapid progress being made in radiology.

As to its practicability there can be no argument. Socially it was all that could be desired. From an economic viewpoint, it saved many members the time and expense of two journeys.

The American manufacturers of apparatus of all standard types, equalling or perhaps surpassing any made in the world, were represented by splendid collections, which were of distinct advantage to the radiologists present. The N. V. Philips Company, of Eindhoven, Holland, brought over an extensive exhibition of their products.

It is to be hoped most sincerely that those who direct the policies of the various radiological bodies will seriously consider the question of a feasible simultaneous group meeting. Such an act will earn the everlasting gratitude of all concerned. If one may venture a suggestion, these proposed annual meetings could well be held in the fall, as far removed as possible both in time and place from the annual meeting of the American Medical Association.

The Chicago Congress will live in history. Its official program, the book "Science of Radiology"—its portrait catalogue, veritable reference works of the highest order, will serve as treasured mementoes. The committee in charge catalogued the exhibit adequately, while the rare books were reviewed in an interesting style.

Much credit is due the committees whose untiring work made the Congress possible, and under whose capable management it functioned so smoothly. To Benjamin H. Orndoff, M.D., especial acknowledgment is due.

ALBERT SOILAND, M.D.

ABSTRACTS OF CURRENT LITERATURE

CONTENTS BY SUBJECT

CONTENTS OF ABSTRACTS IN THIS ISSUE, LISTED ALPHABETICALLY BY AUTHORS

FRACTURES (THERAPY)

Circulation of the Head and Neck of the Femur: Its Relation to Non-union in Fractures of the Femoral Neck. W. Eugene Wolcott. Jour. Am. Med. Assn., Jan. 7, 1933, C, 27.

Since the appearance of Santos' publication in 1930 a careful study of all x-ray films has been made in 79 cases of fracture of the hip. In no instance was there roentgen evidence of necrosis of the head or neck of the femur among 38 intertrochanteric fractures. Throughout the entire number of roentgen examinations in these cases, the relative density of the fragments of the head and neck seemed to remain constant with that of the shaft. Of the intracapsular group, however, in 11 cases in which non-union existed, definite changes in the relative density of the free head and the upper shaft were seen. In six of these the femoral head cast a shadow of definitely increased density when compared with the shaft. In five cases, on the other hand, as time progressed more and more mottling developed, distributed irregularly throughout the proximal fragment. In two cases a well-pronounced wedge-shaped area of localized resorptive rarefaction extended inward with the base of the wedge at the fovea. Except for this area, the density of the remaining portion of the proximal fragment was increased.

In the 15 cases in which non-union resulted, early beginning absorption of the femoral neck was noted. Subsequent roentgenograms taken at regular intervals in each instance showed that, once resorption in the area of the neck began, it progressed until the entire neck had disappeared. Later the fractured surfaces became capped by sclerotic bone, which showed in the roentgenograms as lines of definitely increased density. The author concludes that the ligamentum teres carries a definite blood supply to the head of the femur regardless of the age of the subject. This blood supply is a definite factor in maintaining the nourishment of the head of the femur in cases of intracapsular fracture. Operations for repair of non-union in the neck of the femur should be planned and executed in a manner which will not disturb or injure the vessels coming through the ligamentum teres, nor should foreign material approximate too closely the foveal area.

CHARLES G. SUTHERLAND, M.D.

THE PELVIS

Suprapubic Cystotomy and the Prevention of Pelvic Cellulitis. L. T. Mann. Am. Jour. Surg., March, 1933, XIX, 505-508.

The author finds that only 8 per cent of autopsied cases in his series died of perivesical suppuration, which is not in keeping with the opinions of other authors that this is the main cause of death in suprapubic cystotomy. Twenty-four autopsies were on prostatectomized cases. Two died of pelvic cellulitis, which is 8.3 per cent of the autopsied, or 0.3 per cent of all prostatectomies. Of 16 deaths after simple cystotomy for relief of prostatic obstruction, in which autopsy was done, one (6.2 per cent) died of perivesical suppuration.

Finally, of those who died after suprapubic cystotomy for conditions other than prostatic adenoma,

autopsy showed 1 in 10 deaths to be due to pelvic cellulitis, a 10 per cent rate.

Therefore, in performing suprapubic cystotomy with his technic, which establishes adequate drainage of the space of Retzius and the wound, perivesical suppuration can be prevented, and is not and should not be the predominant dangerous complication and the prime cause of death.

DAVIS H. PARDOLL, M.D.

PEPTIC ULCER (THERAPY)

Traumatic Ulcer of the Duodenum and Stomach. Burrill B. Crohn and Julius Gerendasy. Jour. Am. Med. Assn., May 27, 1933, C, 1653-1658.

German and French literatures are replete with illustrative examples and references and not only recognize the existence of this entity, but describe in detail the *modus operandi* of the trauma, the clinical manifestations that accompany the formation of the lesion, and the clinical course of this unusual ulcer syndrome. A woman, aged 45, with no history of previous digestive disturbances or complaints, was violently thrown out of a seat of a bus, catapulted across the aisle, so that the epigastric area of the abdomen forcibly struck a projecting edge of the opposite bench. She complained of the pain but was able to proceed to her home. The next morning she felt a less severe epigastric distress; on evacuation of the bowel she noted that the stools were black. Two days later, she felt nauseated and vomited a large quantity of blood. Upon the woman being removed to a hospital, the hematemesis was repeated several times, associated with melena. The subsequent course of the case has been characteristic of a typical duodenal ulceration. Roentgenographic studies corroborated the presence of a duodenal ulcer. After a two-year period the persistence and severity of the symptoms brought up the question of surgical intervention.

A comprehensive review of the literature leads to the conclusion that traumatic ulcer of the stomach and duodenum does exist.

C. G. SUTHERLAND, M.D.

RADIUM

Poisoning from Drinking Radium Water. Alexander O. Gettler and Charles Norris. Jour. Am Med. Assn., Feb. 11, 1933, C, 400-402.

The case described is the first on record to be diagnosed correctly as radium poisoning, caused by drinking radium water, in which the autopsy and analysis of the tissues corroborated the diagnosis. The patient, aged 52, had been drinking a water said to contain 2 micrograms of radio-active substance in each 60 c.c. bottle, and had consumed about 1,400 bottles. During the few months he was in the hospital the air he expired was found to be radio-active. Four weeks before death a part of the jaw, which was necrotic, was removed by operation. The autopsy revealed necrosis of the jaw bones, swollen kidney cortex, cerebral abscess of the right temporosphenoidal lobe, moderate coronary sclerosis of the aorta, and marked hyperplastic bone marrow (regenerative type) (bright red bone marrow). The heart, liver, lungs, spleen, and kidneys, and portions of the femur, vertebræ, ribs, jaw bone, and teeth were taken for analysis. The preparation and examination of these tissues are taken up in detail. The presence of radium was proved by both the electroscopic and the photographic methods. The total amount of radium in the entire body was 73.66 micrograms.

C. G. SUTHERLAND, M.D.

STOMACH (ROENTGENOGRAPHY)

Primary Actinomycosis of the Stomach: Report of Case. Alexander W. Blain. Jour. Am. Med. Assn., Jan. 21, 1933, C, 168, 169.

No cases have been reported in this country, while apparently there is but one authentic case in the European literature. A Scotch die-maker, aged 37 years, had served for 5 years in the tank forces of the British Army, had been gassed several times, and had had shrapnel removed from his arms, legs, and head in 1914 and 1919. Following the War he had worked at repairing trucks in a factory. He came directly from Europe to America. Five months' history of epigastric pain and gas on the stomach was given, the symptoms being pain one hour after eating, relieved by food or baking soda. Roentgen studies showed deformity of the stomach, with some delay at the pylorus but no definite obstruction. The interpretation was chronic gastric ulcer. Subtotal gastrectomy was done; microscopic examination of the specimen showed a chronic granulomatous reaction with dense lymphocytic and plasma cell infiltration, necrosis, suppuration and abscess formation. Post-operative condition was poor; was readmitted a month after discharge with subphrenic or hepatic abscess. He was discharged again and was quite well for a time, but three months later diarrhea developed with extreme emaciation and cachexia. He died the day following readmission and autopsy showed abscess nodules in the liver exhibiting the characteristic honeycombing of actinomycosis. Serial sections of the original sections from the stomach were made and in about 300 slides a dozen were found in which the ray fungus could be identified.

C. G. SUTHERLAND, M.D.

Sacs, Pockets, and Localized Hypertrophy of the Mucosa in the Post-operative Stomach. R. Prévôt. Röntgenpraxis, February, 1933, V, 101-107.

Post-operative disturbances in a stomach after resection or gastro-enterostomy need roentgenologic examination, in order to clear up the anatomical or functional factors. The formation of sacs, pockets, and localized hypertrophy of the mucosa has been described by Berg, but has not received the attention it deserves.

Localized dilatations of the jejunum opposite the anastomosis with an intact mucosa are called sacs by the author. The explanation of this is probably that the loop of the jejunum, stretched during the operation and in a relaxed condition, retracts again and forms a localized dilated sac. If the sac is large enough, some degree of temporary retention will develop and occasionally this sac may be larger than the rest of the stomach. Scar tissue or too high insertion of the enterostomy may lead to inflammatory swelling and gastro-jejunal ulcer. The patient's symptoms are dependent on the secondary inflammatory changes and the size of the sac, that is, mechanical factors. They are: loss of appetite, the feeling of fullness after a meal, pain and tenderness in the epigastrium, nausea and occasionally vomiting. The roentgenologic examination shows the sac formation with an intact mucosa.

Pockets are also localized dilatations, but do not show any mucosa-relief; they are according to Berg similar to the pockets seen in the duodenum after a duodenal ulcer, and caused by inflammatory changes and scar tissue (prestenotic diverticula). The symptoms in these cases are due to the inflammatory changes and are of the gastro-jejunal ulcer type.

Localized areas of hypertrophied mucosa are occasionally found in the neighborhood of the anastomosis after gastric resections of the Billroth II type. Their occurrence can be explained by the operative technic which leaves too much musosa at the anastomosis. Inflammatory changes will increase the size of these folds so that sometimes they represent a considerable obstruction which might act as a valve occluding the enterostomy-stoma completely at times. The clinical symptoms are the feeling of fullness even after small meals, pressure over the stomach, nausea, and vomiting. The roentgenologic picture is that of a well circumscribed round filling defect; occasionally a carcinomatous recurrence or enlarged glands pressing on the stomach from the outside may cause the same appearance.

H. W. Hefke, M.D.

ULTRA-VIOLET LIGHT

Studies on the Significance of Pigment for the Ultra-violet Light Protection of the Skin. G. Miescher. Strahlentherapie, 1932, XLV, 201-216.

The pigment of the skin is not the principal factor in light protection; the upper layer of the epidermis is perhaps more important, since it responds to light exposure by thickening, and thus shields the underlying tissue. However, pigment has some protective properties. The author showed in his studies, undertaken on animal skin and on negroes, that pigment absorbs short ultra-violet rays strongly. The difference in absorption between white and negro skin is apparently due to the larger pigment content of the latter.

Ernst A. Pohle, M.D., Ph.D.

Dermatoscopic Findings in Light Reactions of the Skin under the Influence of Sauerbruch-Herrmannsdorfer-Gersonscher (S.H.G.) Diet. Max Popper. Strahlentherapie, 1932, XLV, 235-246.

The author studied the skin capillaries in areas exposed to ultra-violet light in patients who were on the S.H.G. diet. It appeared that there existed an increased susceptibility in the skin, manifesting itself in more severe reactions of longer duration. This can be explained in all probability by an influence of the diet on the blood vessels. There were capillary hematomas and dilatation of the deeper blood vessels.

Ernst A. Pohle, M.D., Ph.D.

The Behavior of the Skin Elasticity during Pregnancy and Its Change Following Ultra-violet Exposure. H. Guthmann, F. Anselm, and H. Papenberg. Strahlentherapie, 1932, XLIV, 443-474.

During pregnancy the calcium content of the blood serum is definitely lower, causing disturbances of the colloid equilibrium in the cells. This leads to a loss of fluid, manifesting itself in a loss of elasticity, which can be shown also in the skin. This phenomenon reaches a maximum in the third month, and then drops until the sixth month, when it begins to rise again, reaching its highest peak toward the end of the pregnancy. Short-time intensive ultra-violet exposure influences the calcium and potassium metabolism so much that this loss of elasticity can be counteracted. The effect of the irradiation lasts about four weeks. The prophylactic ultra-violet exposure of pregnant women is, therefore, recommended.

Ernst A. Pohle, M.D., Ph.D.